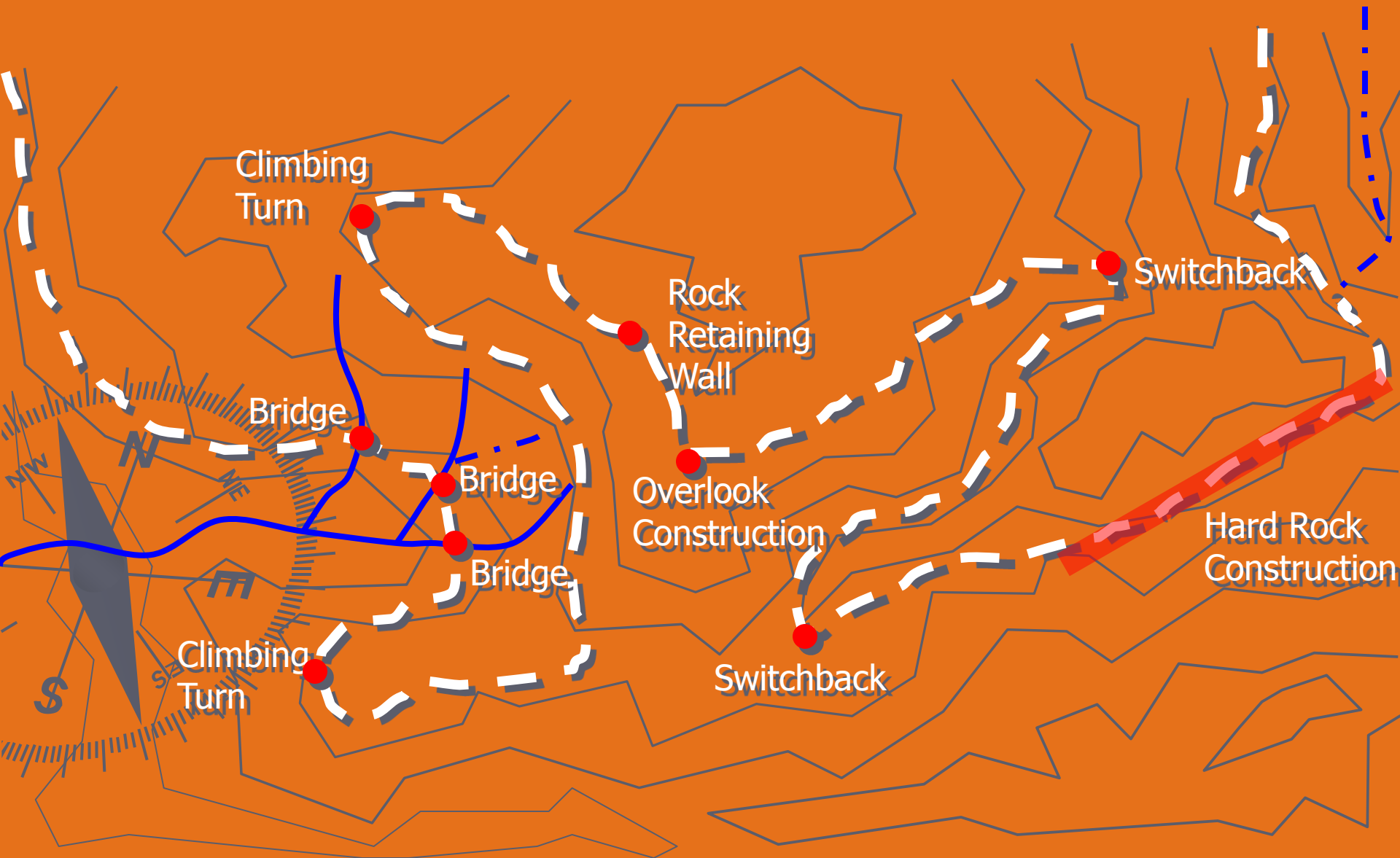
Trail Management, Plans, Projects and People

Maintenance and Construction



Construction and Maintenance

Session Objectives:

- Principles of New Trail Construction
- Trail Maintenance
- When to Use Trail Structures
- Drainage Structures
- Tread Structures
- Trail Step Installation

Construction and Maintenance

- Retaining Walls
- Fences and Railings
- Puncheons and Boardwalks
- Bridges
- Rehabilitation
- Selecting a Trail Structure
- Field Exercise

New Construction

- In Some Cases there is New Construction for a Newly Created Trail
- Most New Construction is a Reroute of an Existing Trail
- Existing Route does not Meet Design Requirements

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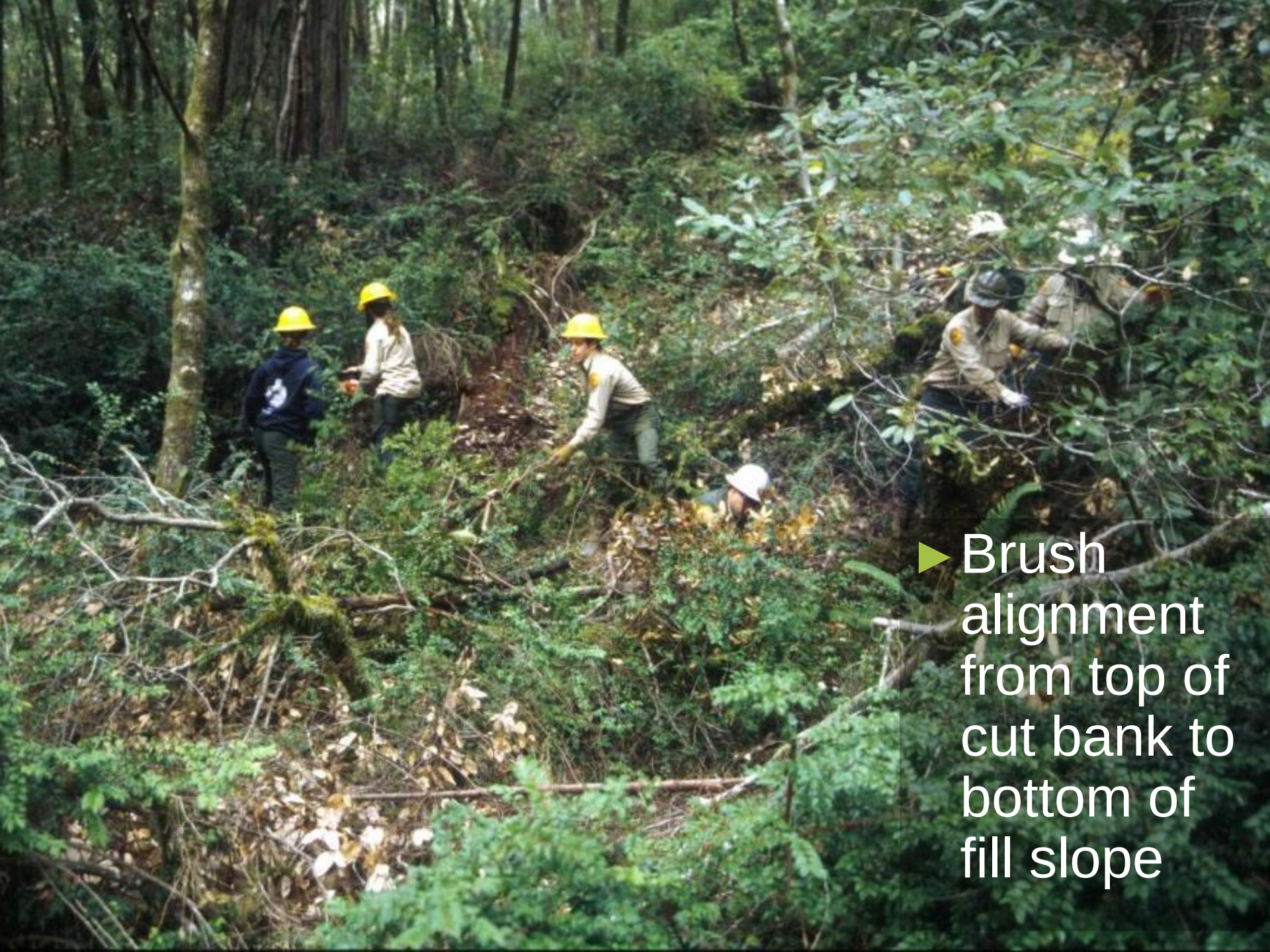
Principles of New Trail Construction

- First Phase of Work
- Orientate and Follow Flag Line Established During Layout and Design Phase



- Brush alignment from top of cut bank to bottom of fill slope

- Corridor Width of Brushing will Vary with Steepness of Sideslope

- Stash all cut material out of sight from Trail Alignment, away from watercourses

- Remove Fallen Logs
- Cut to Design Standard Clearing Limits
- Remove Logs in Maximum Possible Lengths for Potential Use in Structures During Trail Construction


Grub Out/Remove
Small Trees and Shrubs
Including Root Wads

- Remove Organics from Corridor
- Retain “duff” Removed for Covering New Constructed Tread

After the Trail Alignment has Been Brushed and Organics Removed it will Need to be Re-flagged

Trail Construction is Done Similar to Fire line Construction

- Grubbing Tools in the Front and Finishing Tools in the Rear
- Crew Moves Forward as a Unit
- Crew Speed Controlled by the Rear of the Line

Other Types of Construction Techniques

Sometimes the Trail Construction is a Series of Small Projects

Cyclic or Reoccurring Maintenance

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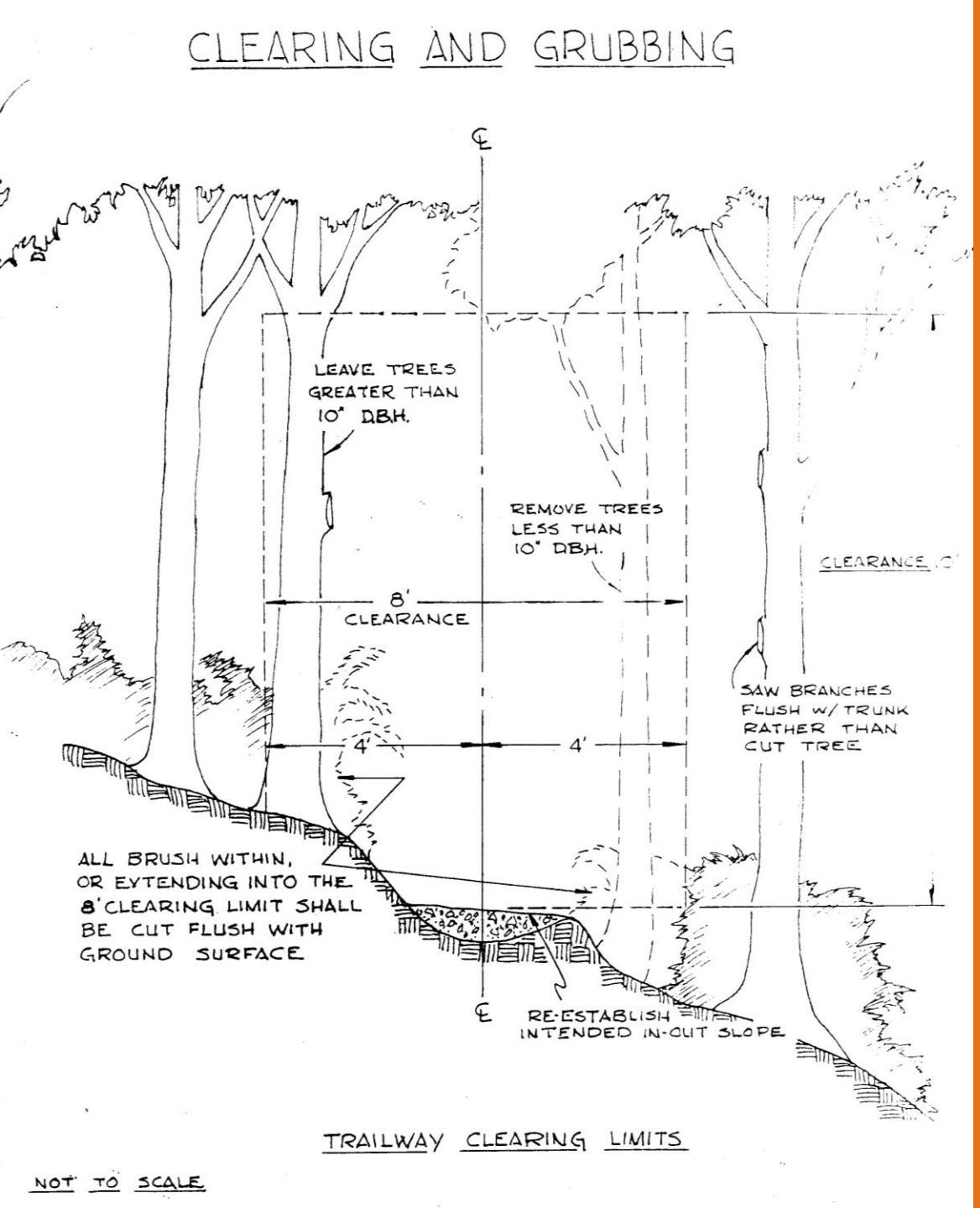
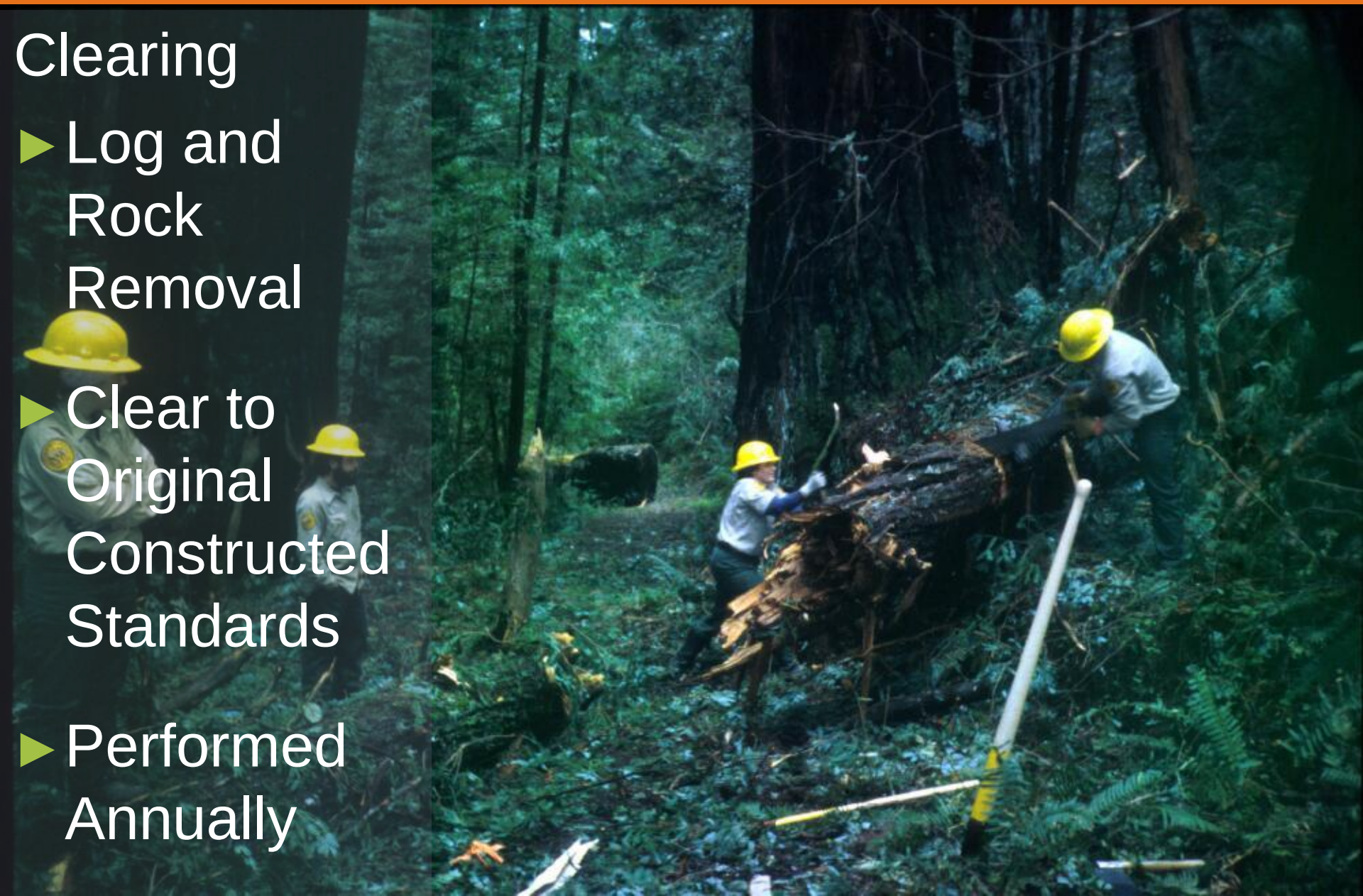


Clearing and Brushing

Clearing Maintenance



Clearing

- Log and Rock Removal
- Clear to Original Constructed Standards
- Performed Annually

Maintenance Brushing

- Cyclic Removal of Dead and Living Vegetation from the Travel Way
- Remove Brush to Standards Based on User Type

Maintenance Brushing

- Cyclic Removal of Dead and Living Vegetation from the Travel Way
- Remove Brush to Standards Based on User Type

Drainage Maintenance

What is the Most Damaging Influence on Native and Gravel Trails?

How Does Water Damage the Trail?

What Do You Do When Water is Eroding the Trail?

Why is Water Getting On the Trail?

- Trail Bed Cut through Seep/Spring
- Diverted Ephemeral or Seasonal Drainage
- Outslope or Crown Eroded or Entrenched
- Poorly Designed Trail Alignment
- Poorly Constructed Drainage Swale

Drainage Maintenance

- Many Trails Managed by Public Agencies and Volunteers are Existing on Bad Trail Alignments
- Options for Reroutes May be Limited
- Proper Installation and Maintenance of Erosion Control Structures May be the Best Option

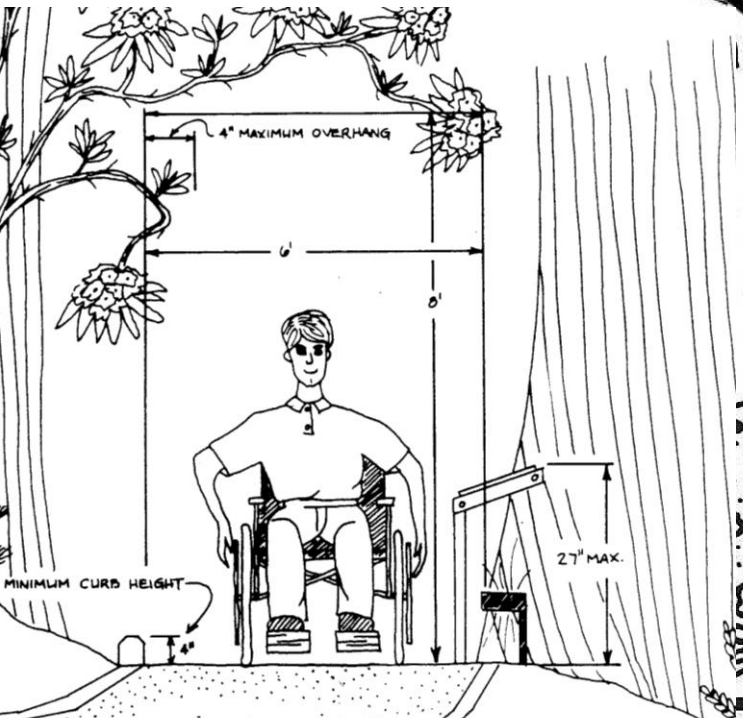
Drainage Maintenance

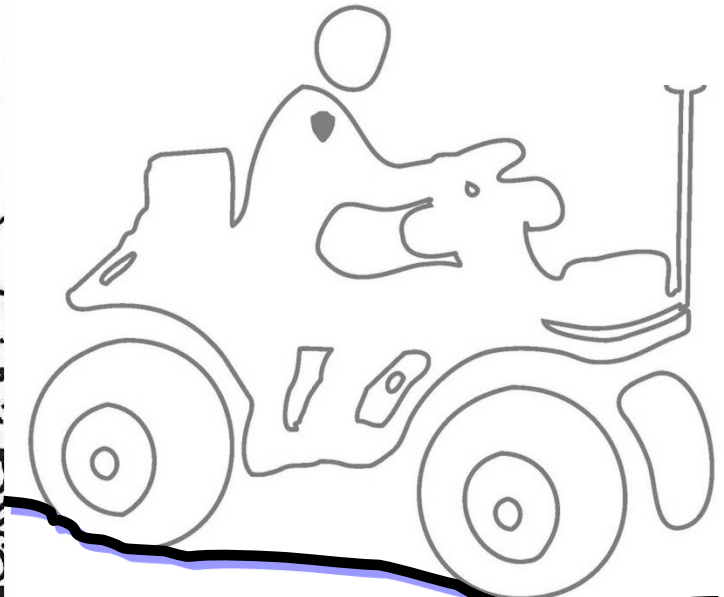
Descending Order of Priority:

- Outslope/Crown Maintenance
- Drain Dips/Armored Drain Swales
- Water Bars
- Check Dams

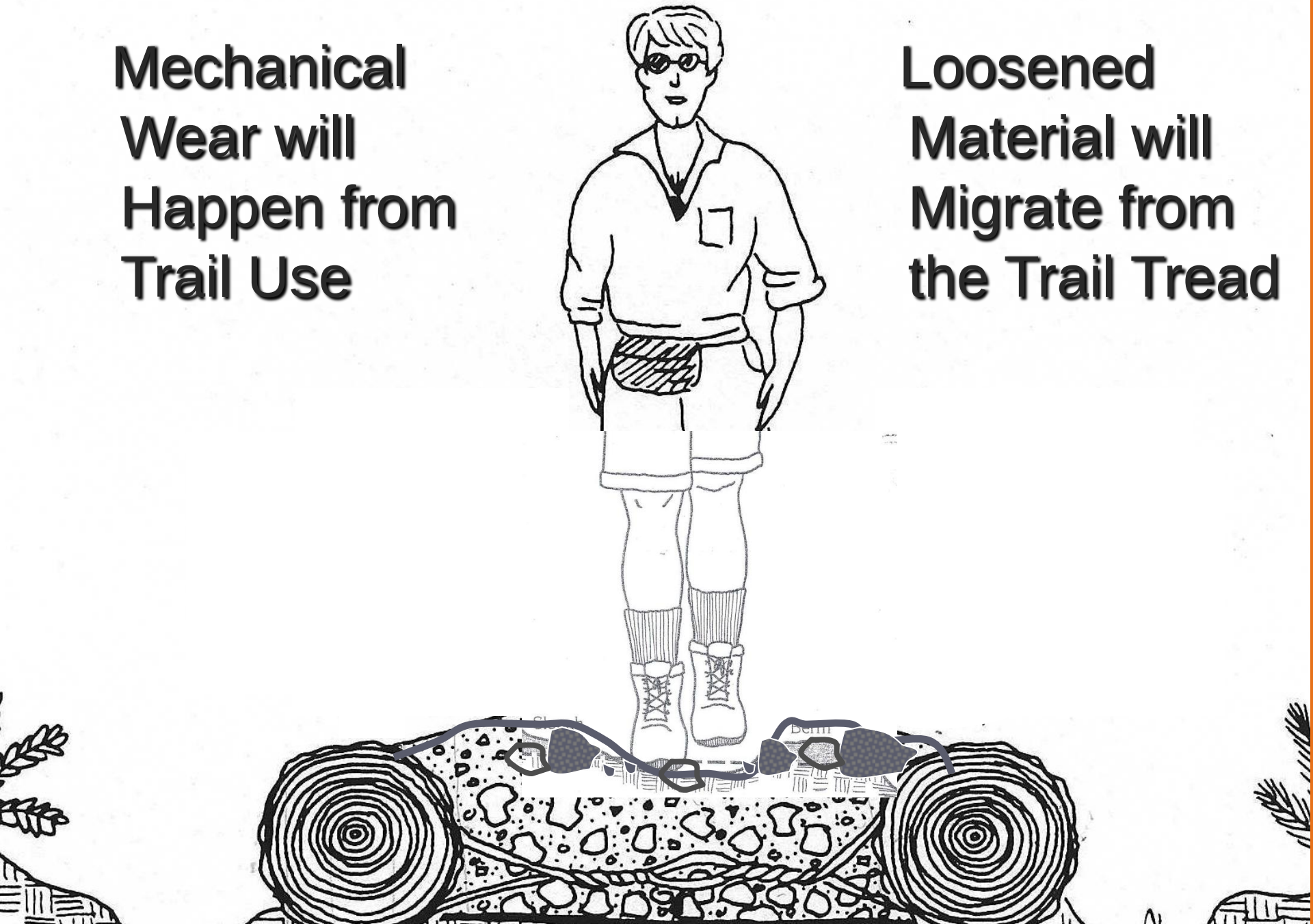
- All Users Have Erosional Impact to the Trail Tread and Designed Drainage


IN.


4" MAXIMUM OVERHANG
6'
8'
MINIMUM CURB HEIGHT
4"
27" MAX.



Mechanical Wear will Happen from Trail Use



Loosened Material will Migrate from the Trail Tread

Outslope and Crown Maintenance

- Slough and Berm Removal

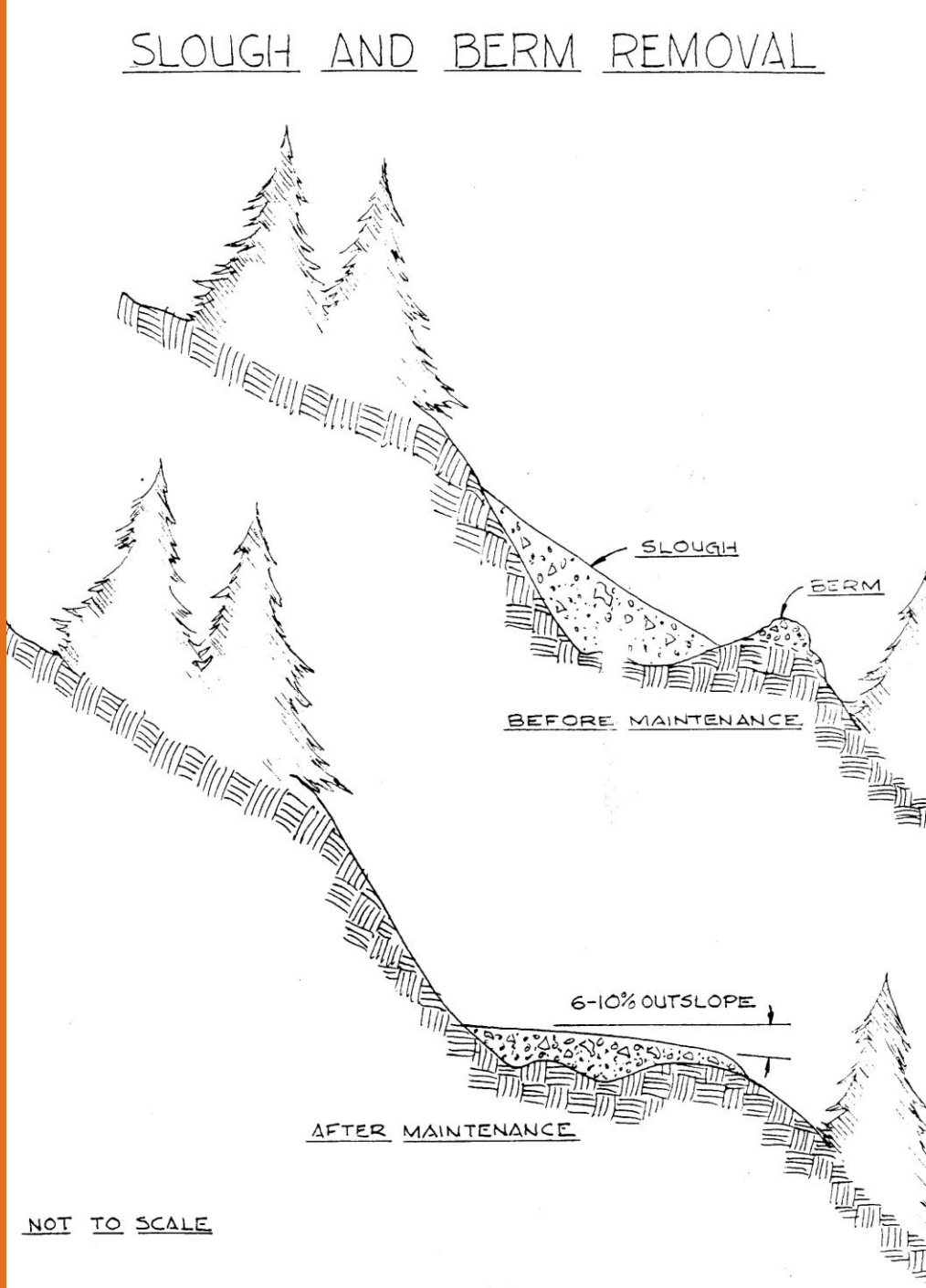
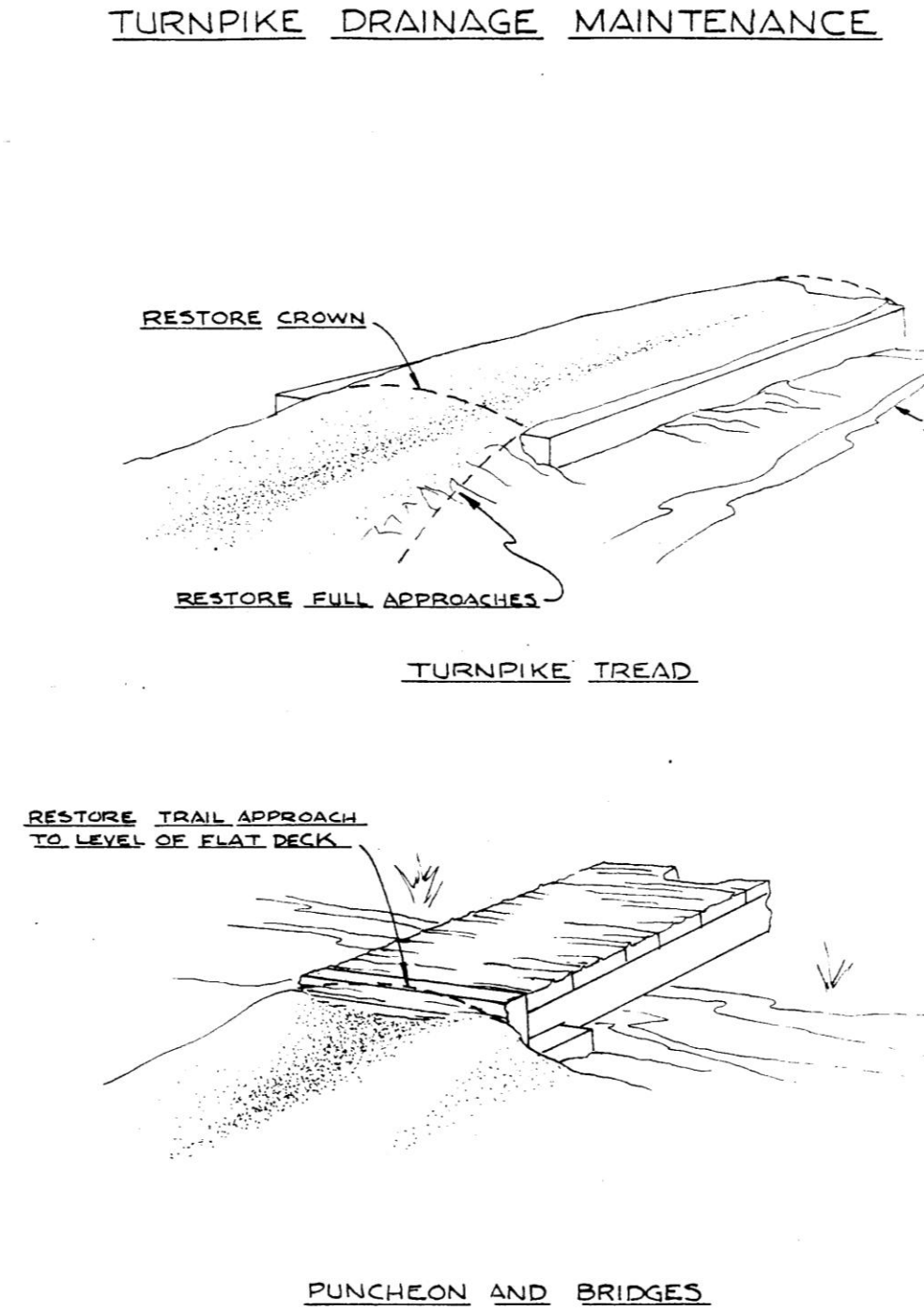


Figure 8.1

Outslope and Crown Maintenance

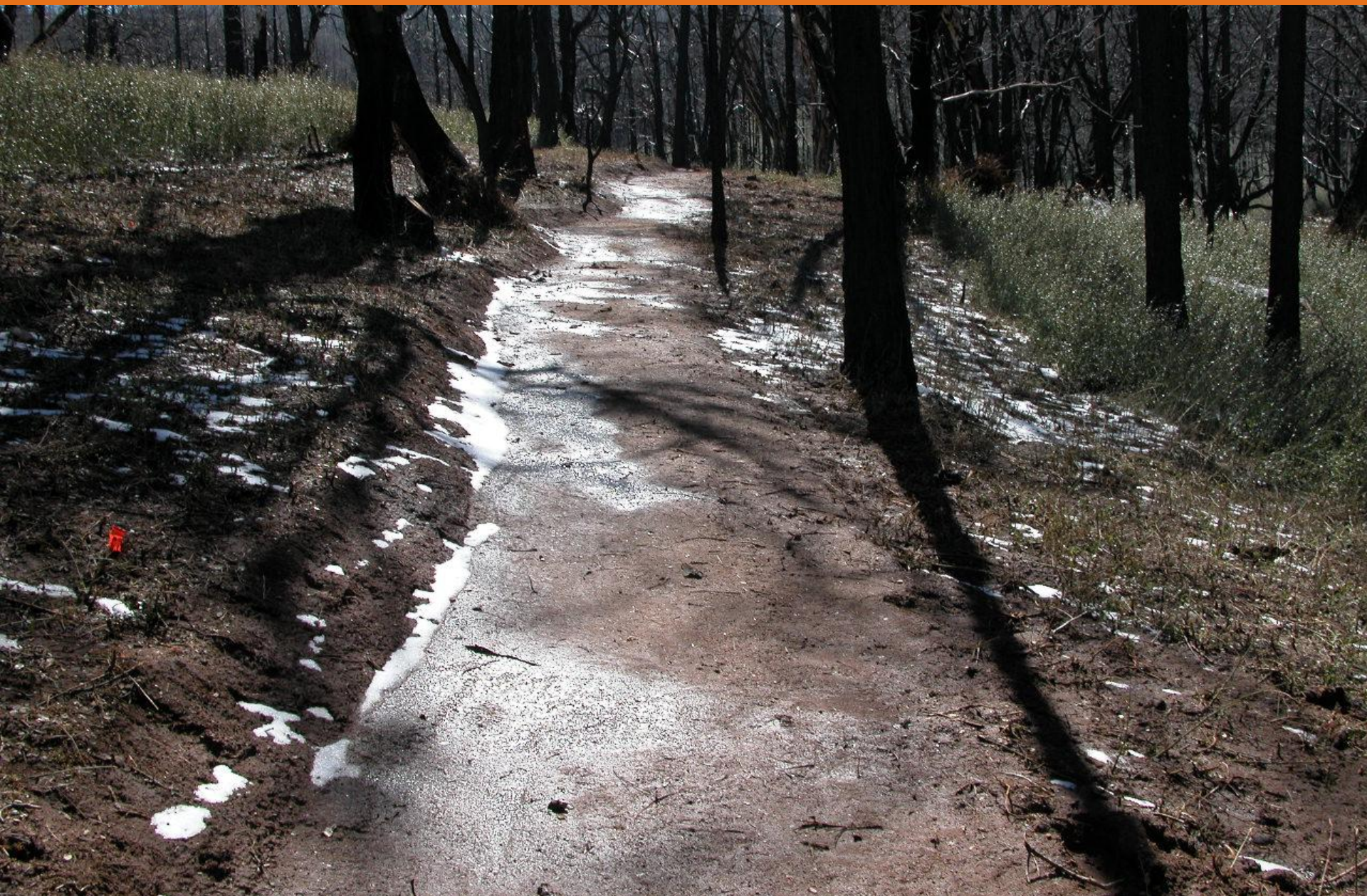
- Slough and Berm Removal
- Maintain Crown on Turnpikes and Causeways



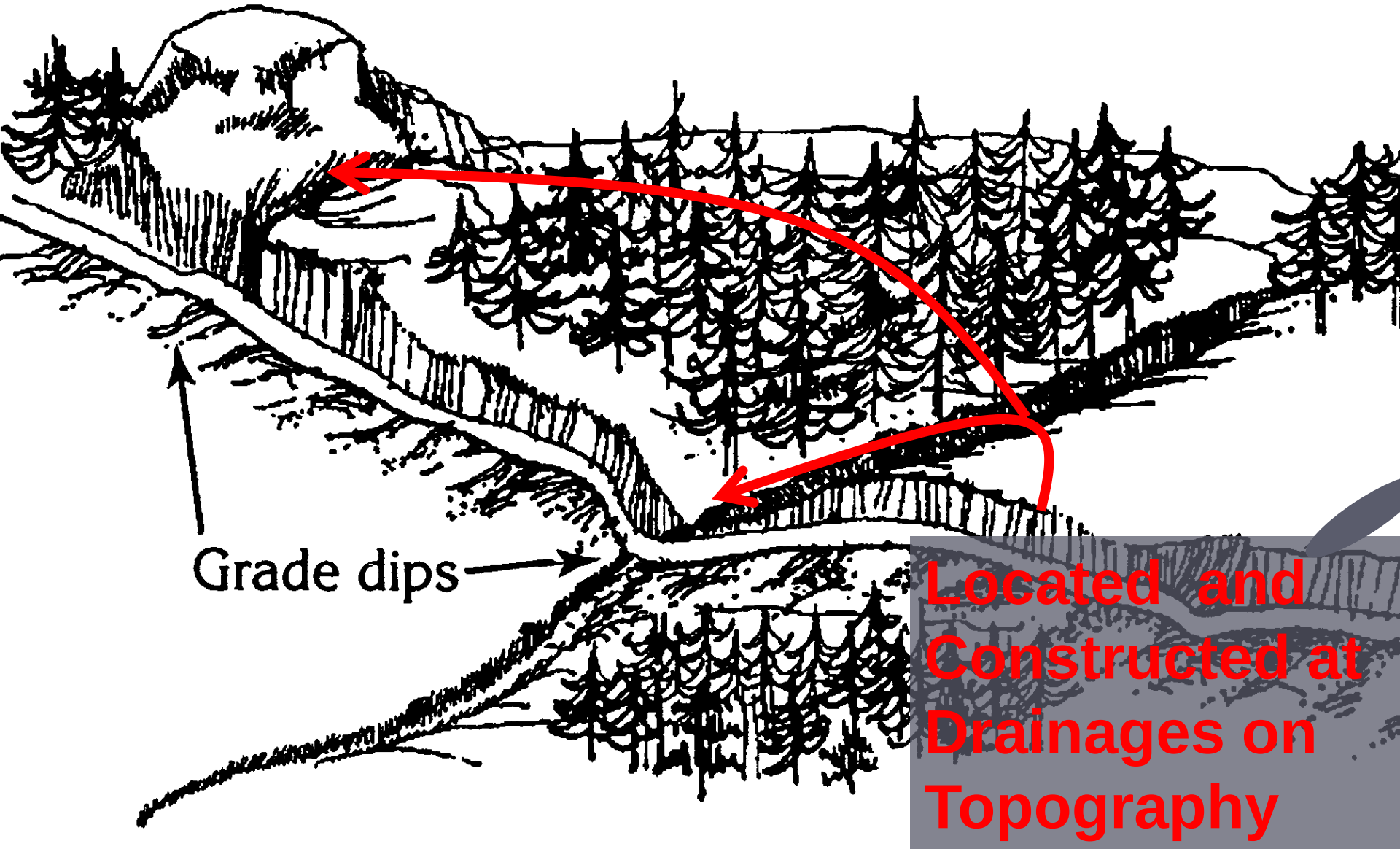
Outslope and Crown Maintenance

- Slough and Berm Removal
- Maintain Crown on Turnpikes and Causeways
- Reconstruct Entrenched Trail

Maintain Sheet Flow



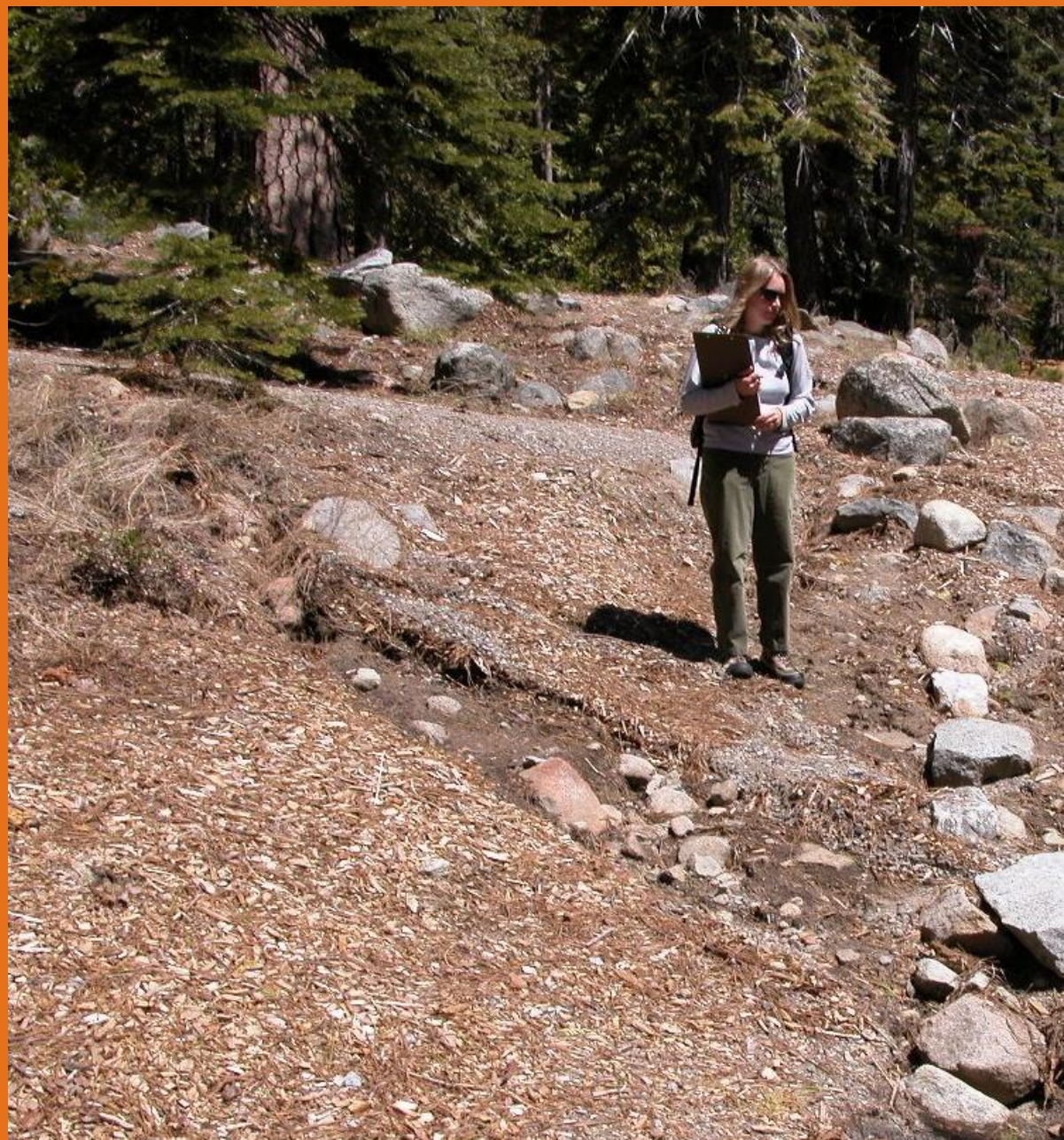
Grade Dips



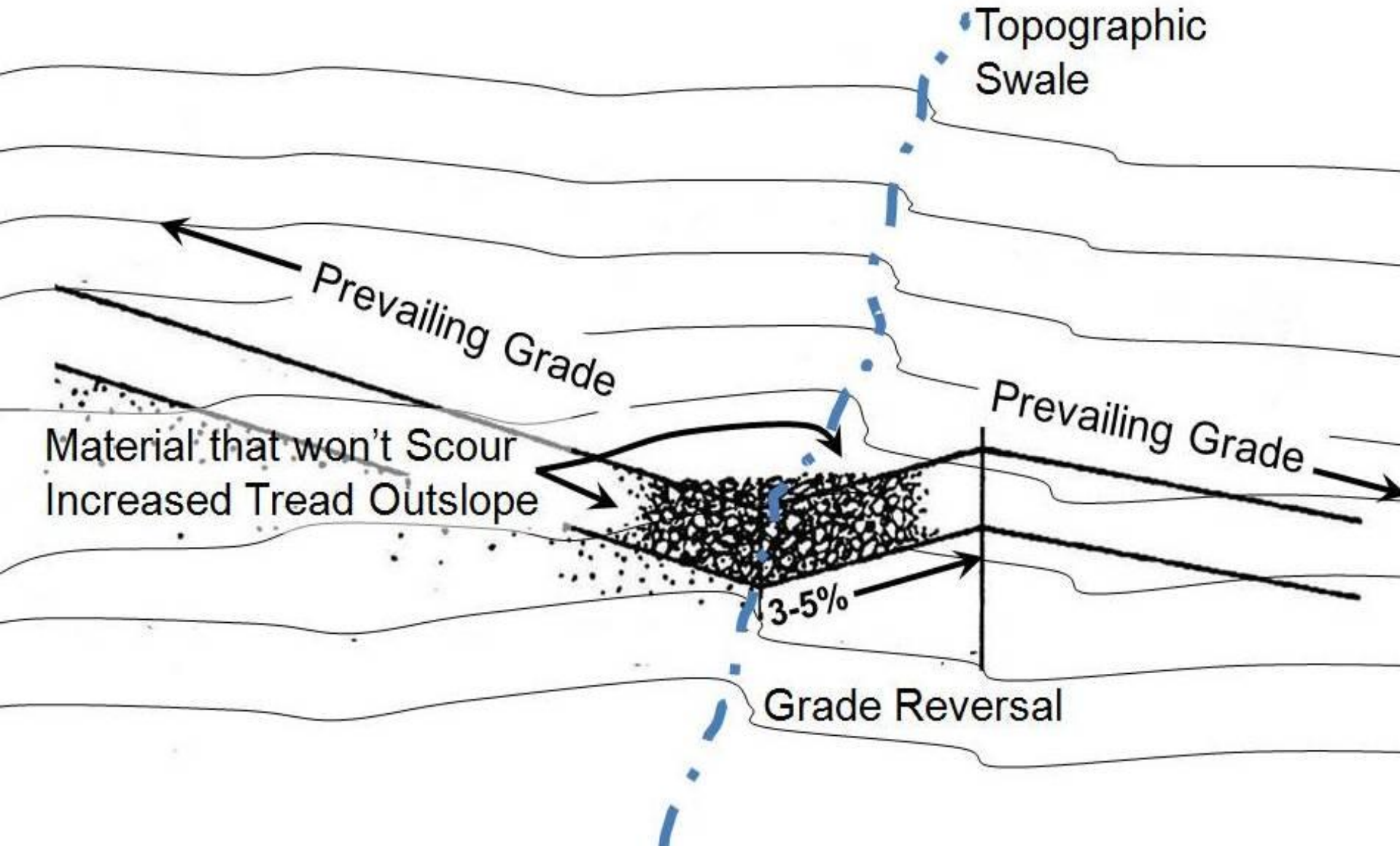
Located and Constructed at Drainages on Topography

Grade Dips

- Not Put In
- Often Placed by Formula
- Placed in Wrong Locations



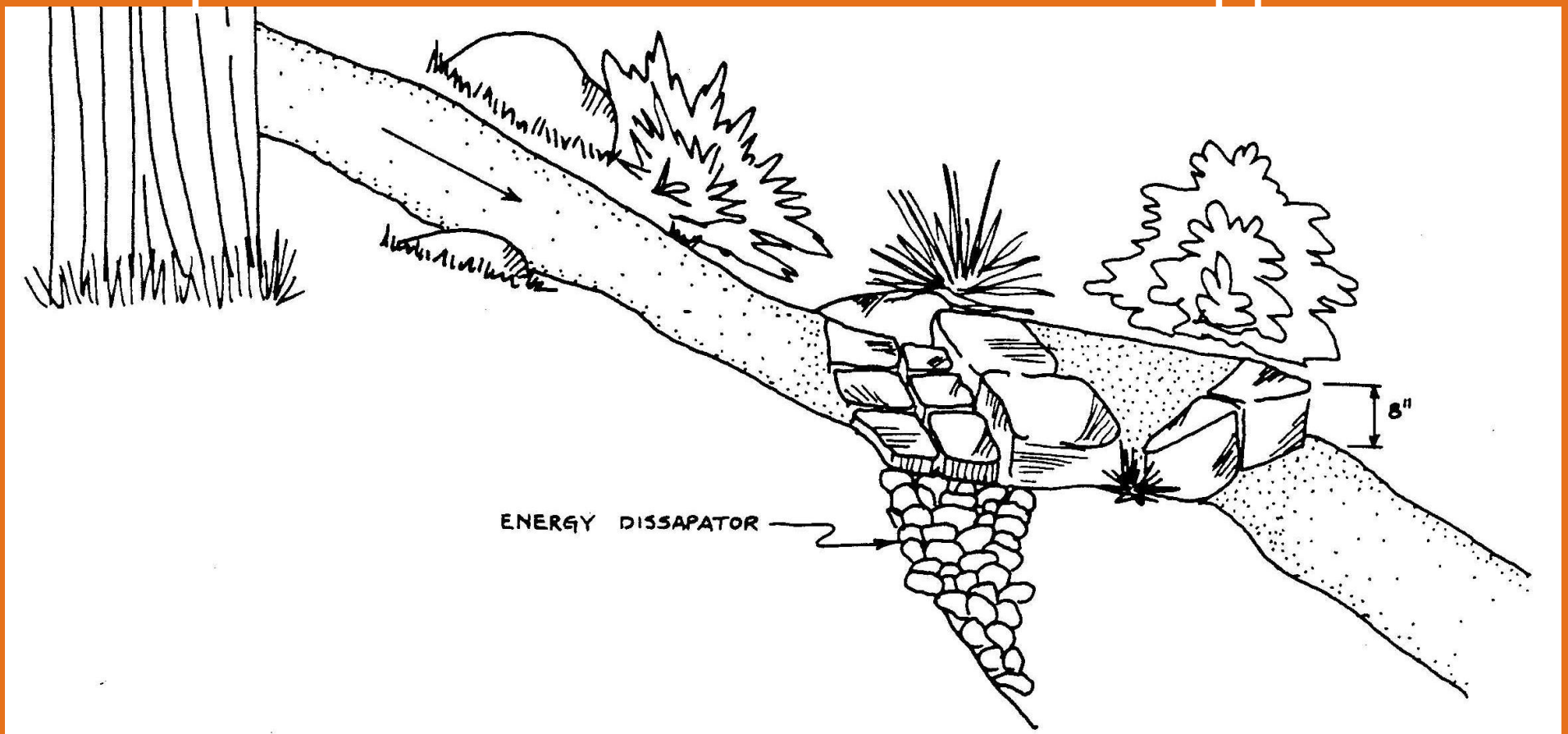
Profile of Grade Dip



Grade Dip at Ephemeral Drainage

Water Bars - Maintenance

- Volunteers Love to Construct
- Must be Placed in Proper Locations
- Require Maintenance That Never Happens



Water Bars - Maintenance

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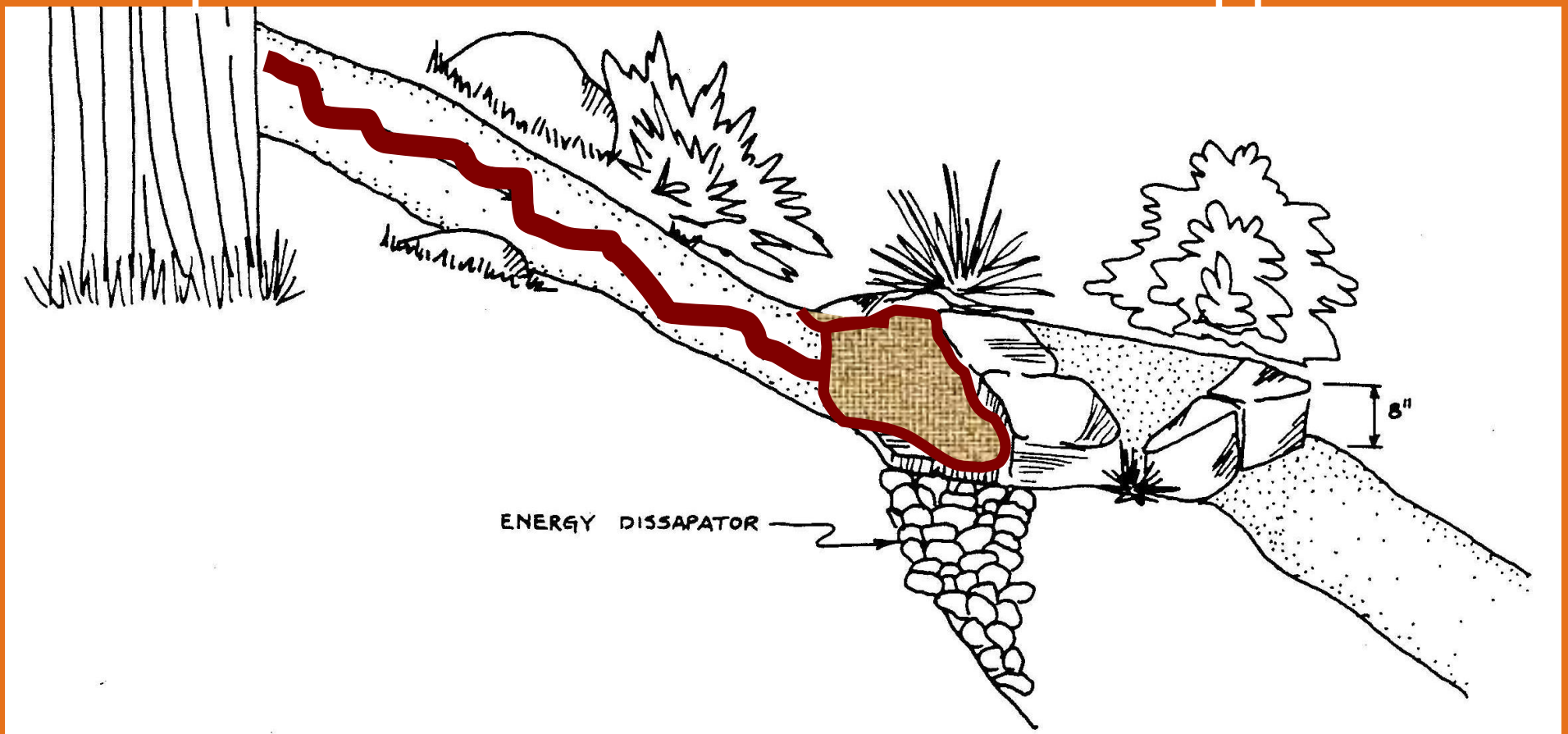
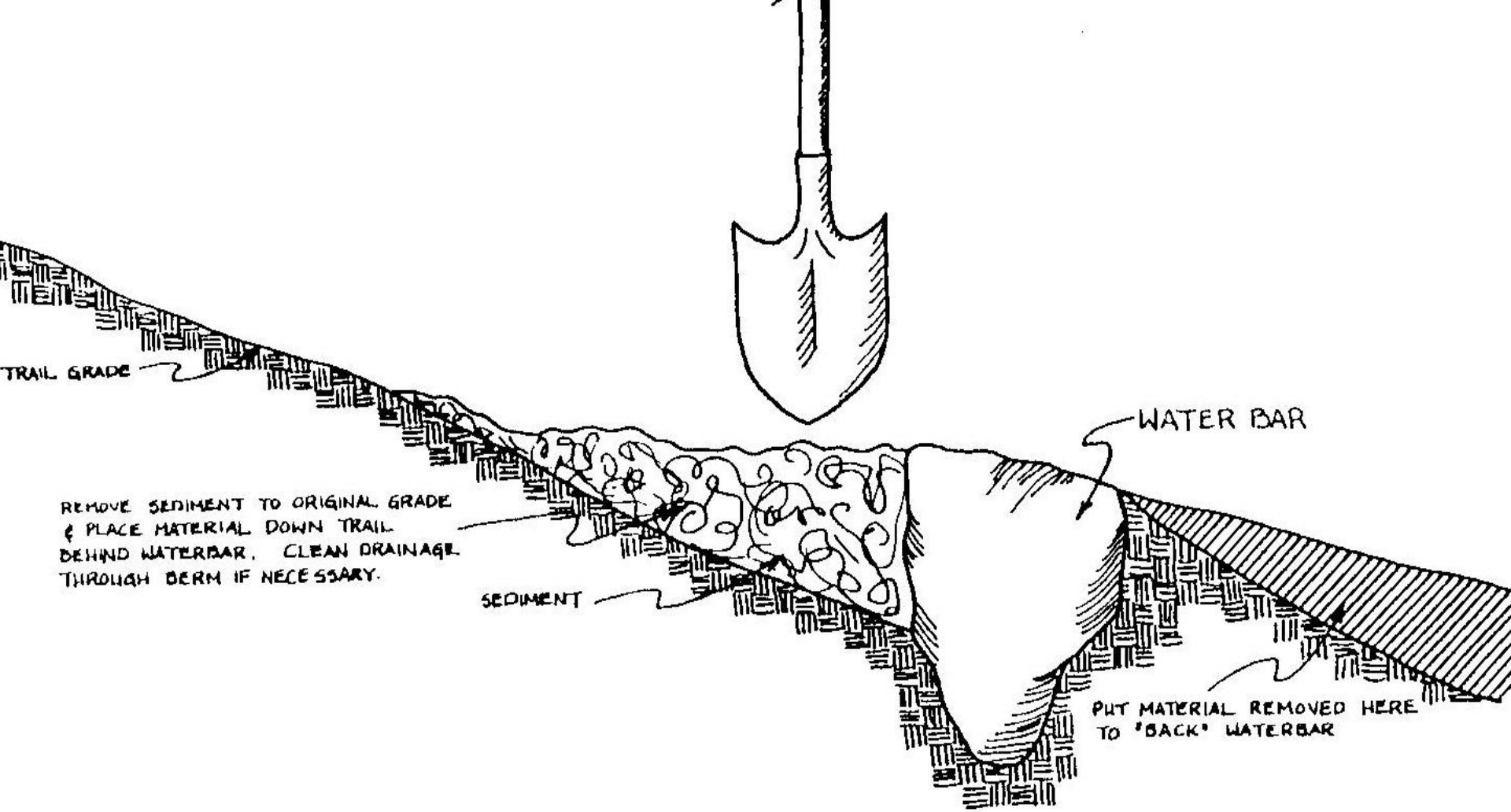




CLEANING A WATERBAR

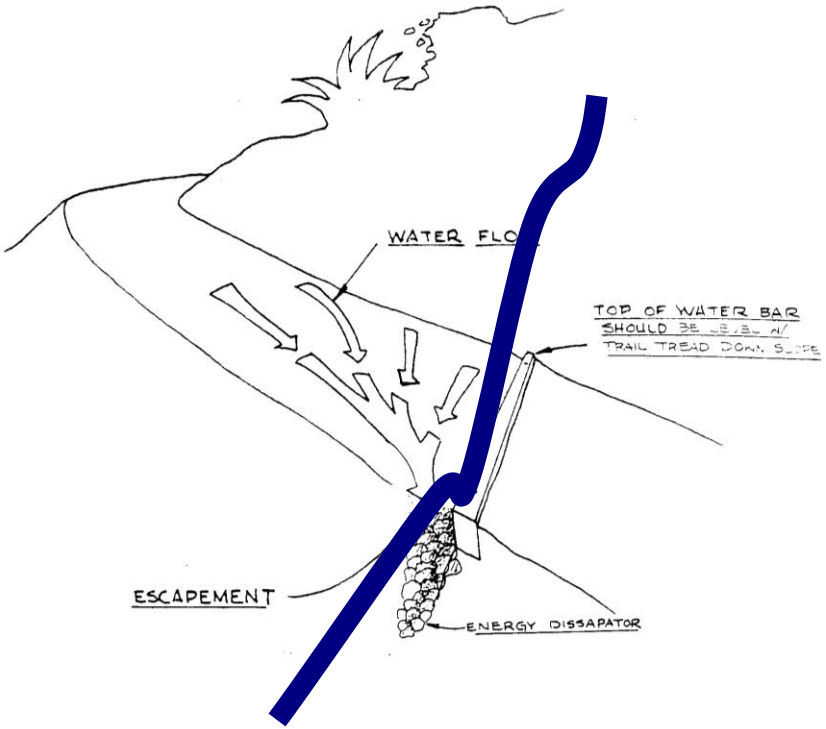
NOT TO SCALE

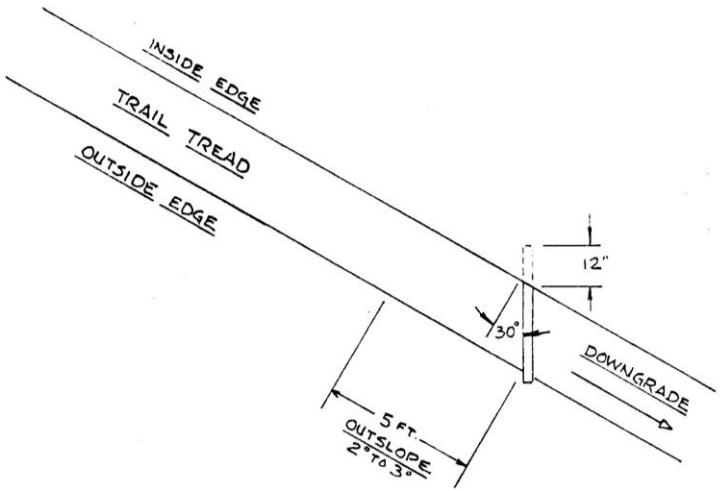
Installation of Water Bars

Water Bars are Band Aids to Poor Design

Should be Placed at Ephemeral Drainages

Water is Released in Natural Location





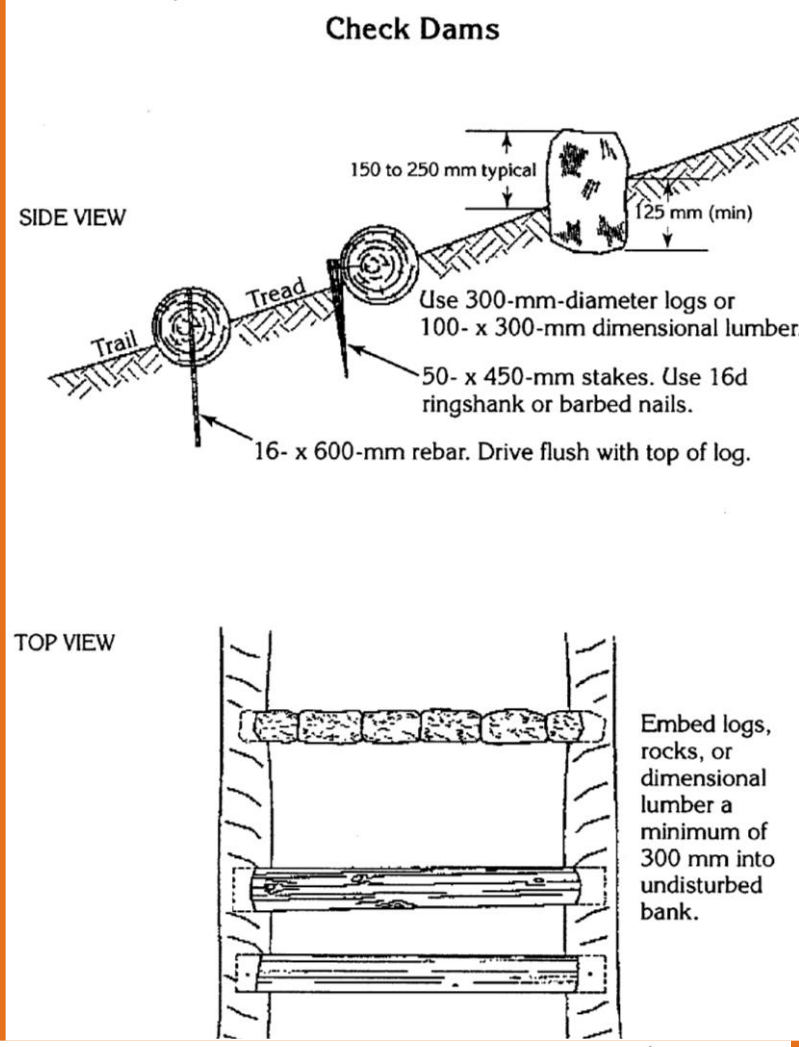
WATER BARS

Only Place Water Bars where Drain Dip will Not Sustain Due to Mechanical Wear

Place at Drainage Source

Check Dams

- Used in Severely Eroded Trail Beds
- Stop Gap Measure to Slow Erosion
- Typically in Fall Line Trails




Zion
National Park

Trail Structures

What is a Trail Structure?

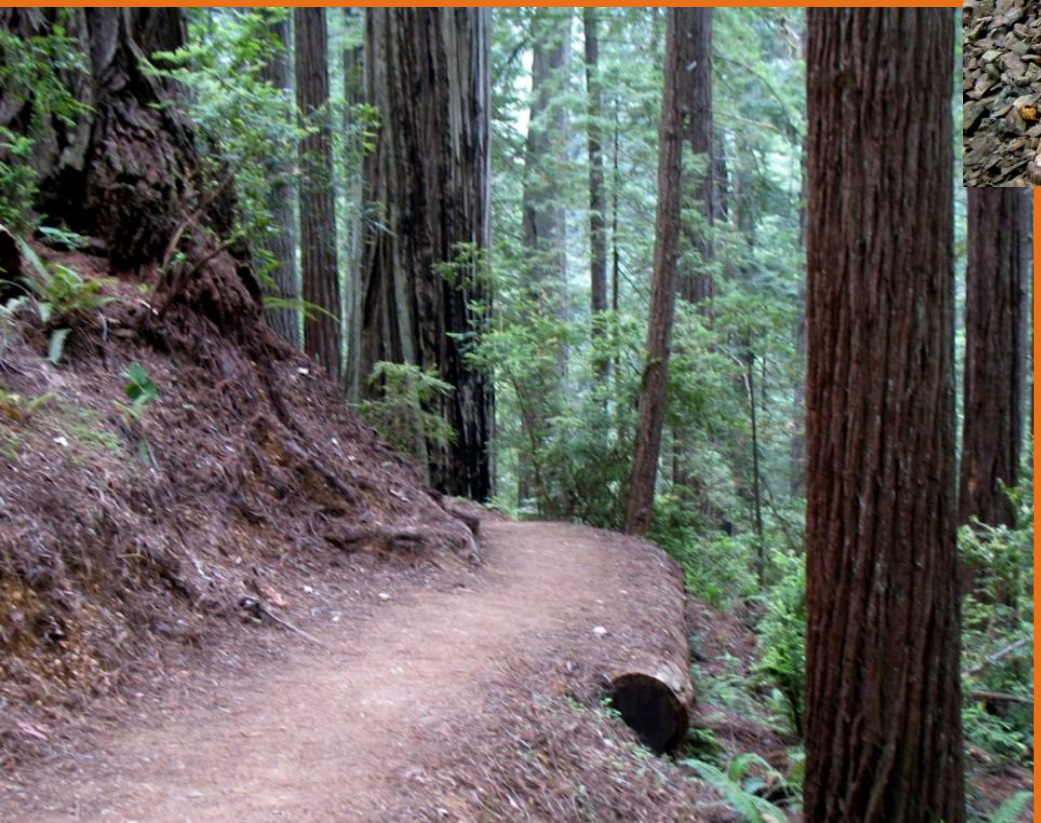
- A Designed and Constructed Trail Feature
- Needed to Augment or Modify the Natural Landform
- Facilitates the Intended Trail Alignment

When is a Trail Structure Required?

- When the Trail Alignment Cannot be Constructed by Simply Excavating a Trail Bench
- Site Conditions (Control Points) that Require Additional Design and Construction work

What are Some of the Conditions that would Require a Trail Structure?

Stabilizing Cut Banks

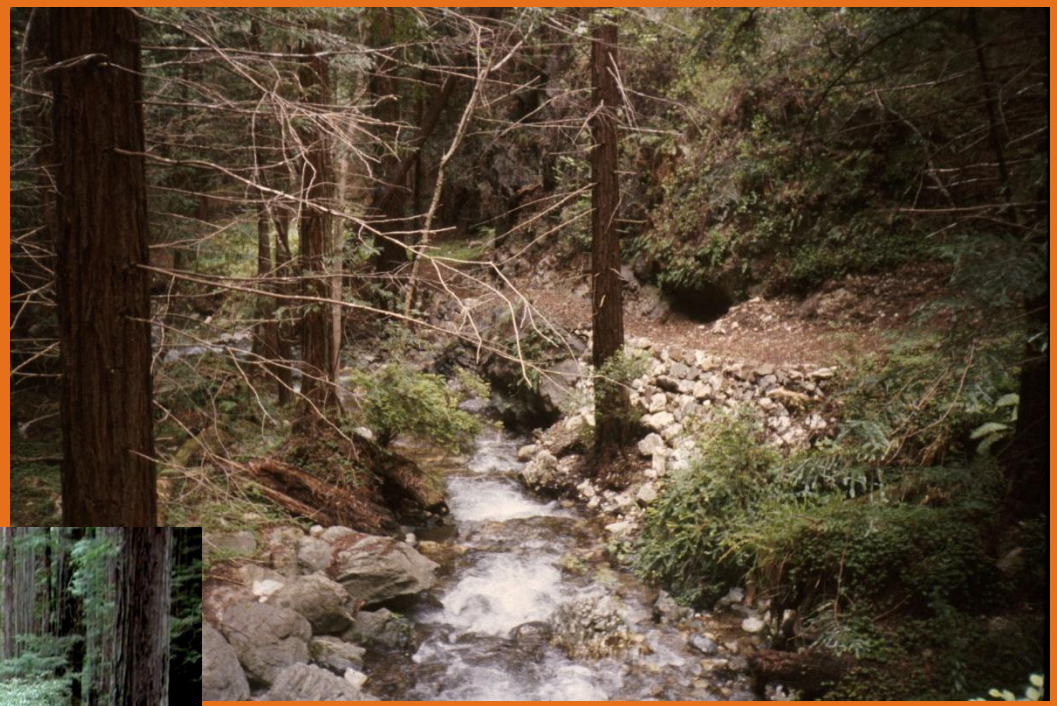


and Fill Slopes

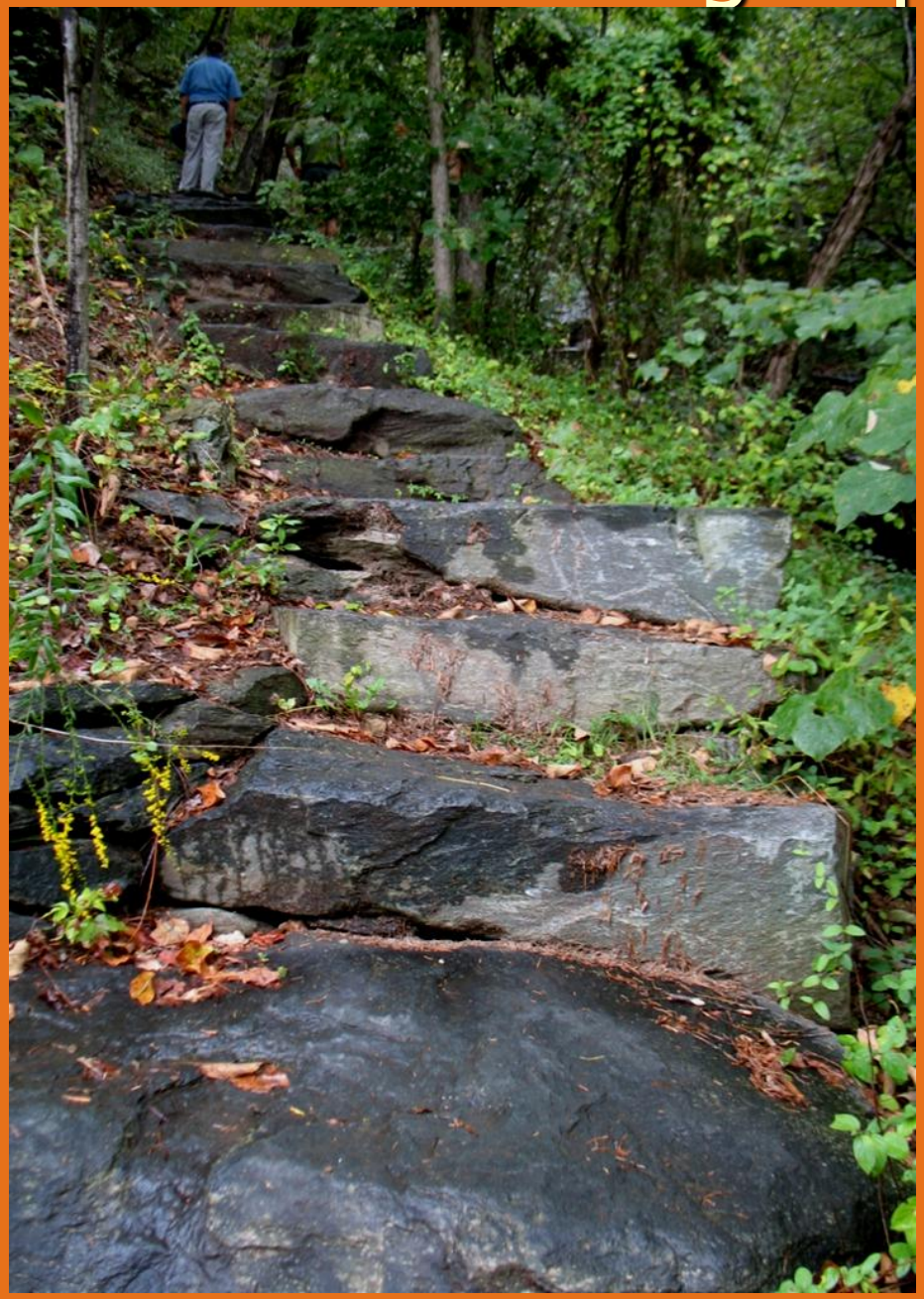
Repair Stream Bank Erosion

Go Around or Through Minor Control Points

Maintain Trail Grade and Protect Resources



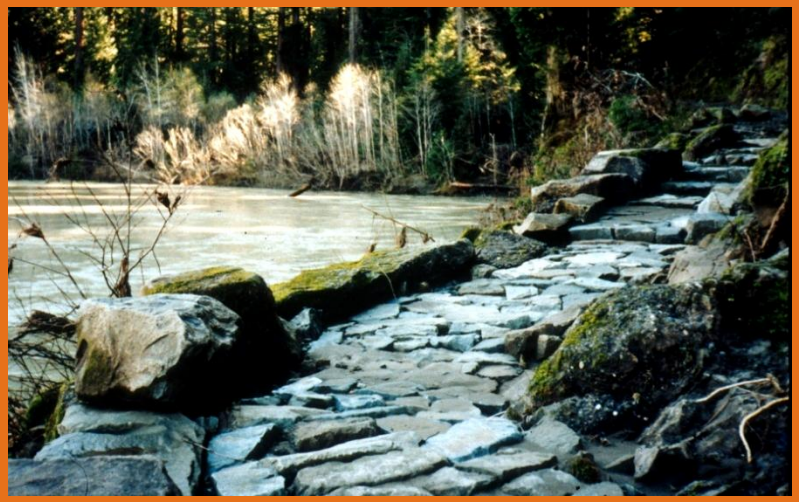
Overcoming Rapid Elevation Gains



Provide Protection from Drop Offs

Crossing Small Drainages

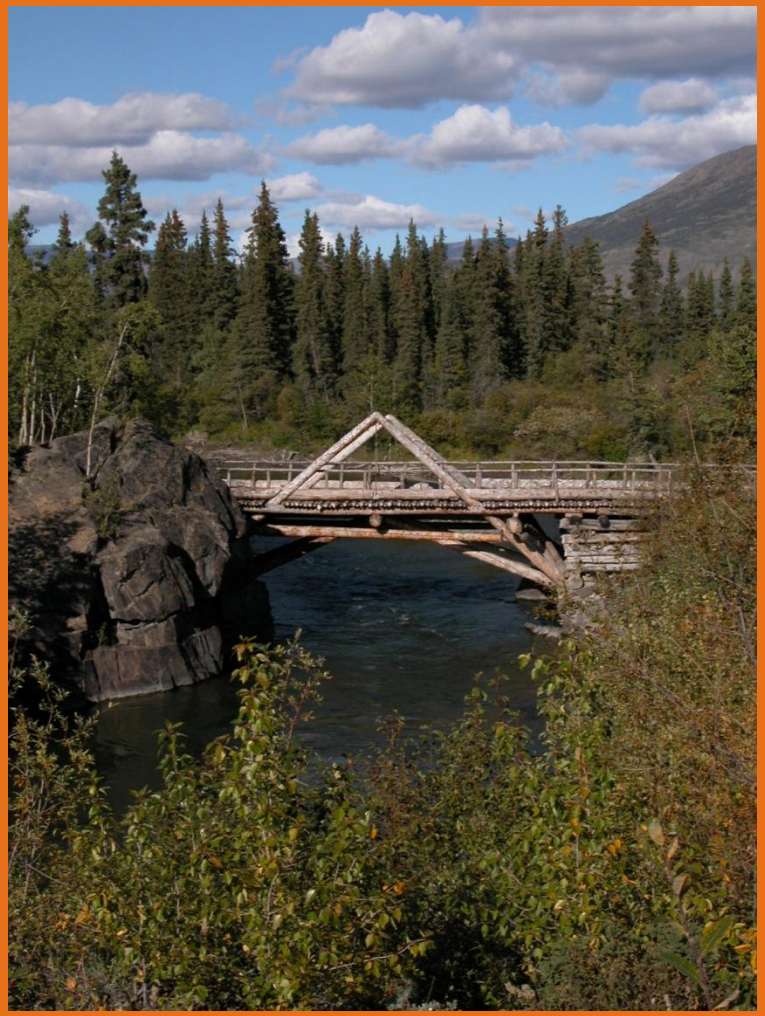
Hardening Saturated Areas



Seasonal Drainage Crossings

To Provide Foundations for Trail Structures

Crossing Large Drainages



Spanning Across Unstable Slopes

Drainage Structures

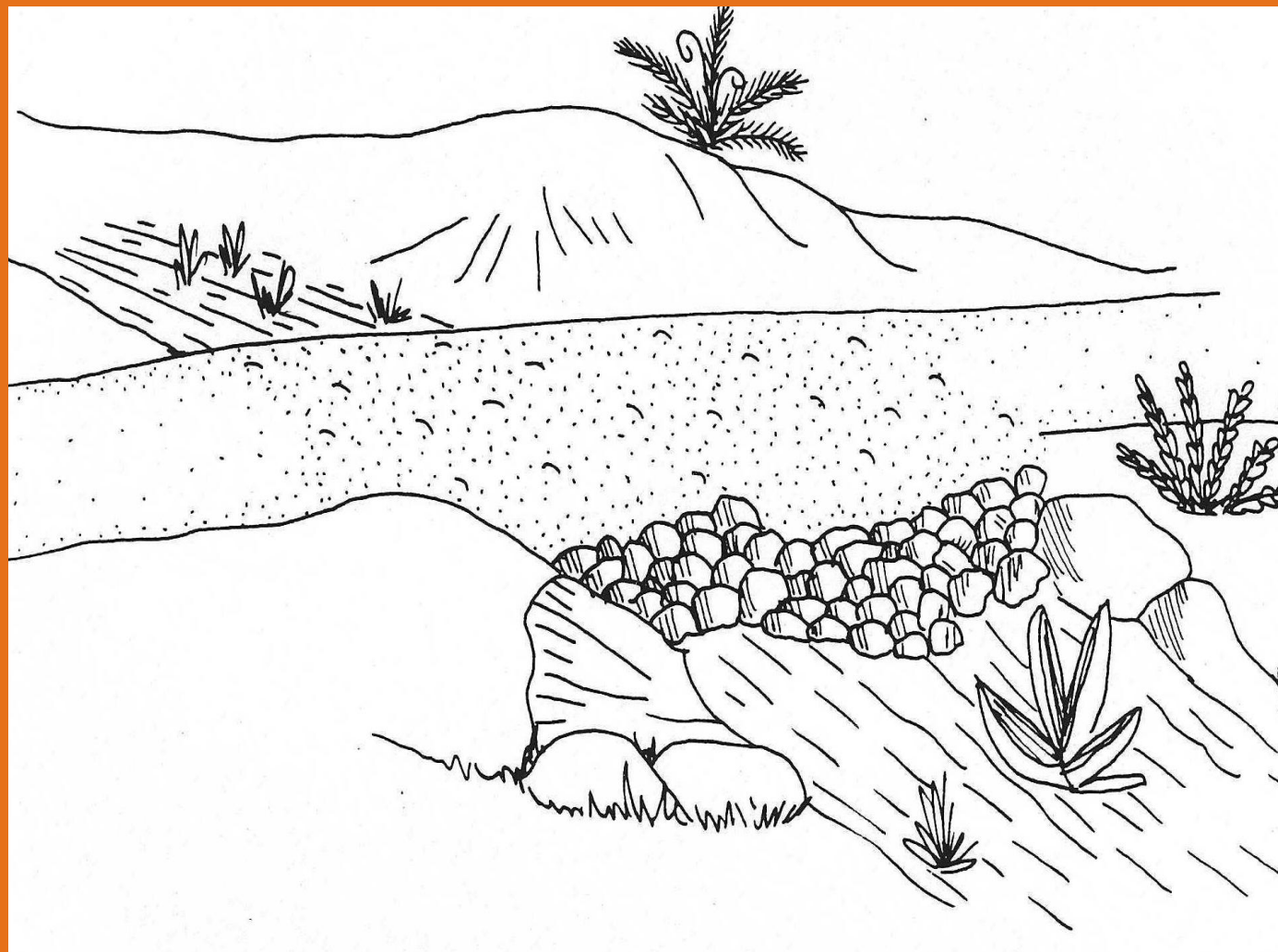
Armored Drain Swales

Drain Lenses or Horizontal French Drains

Drainage Lenses

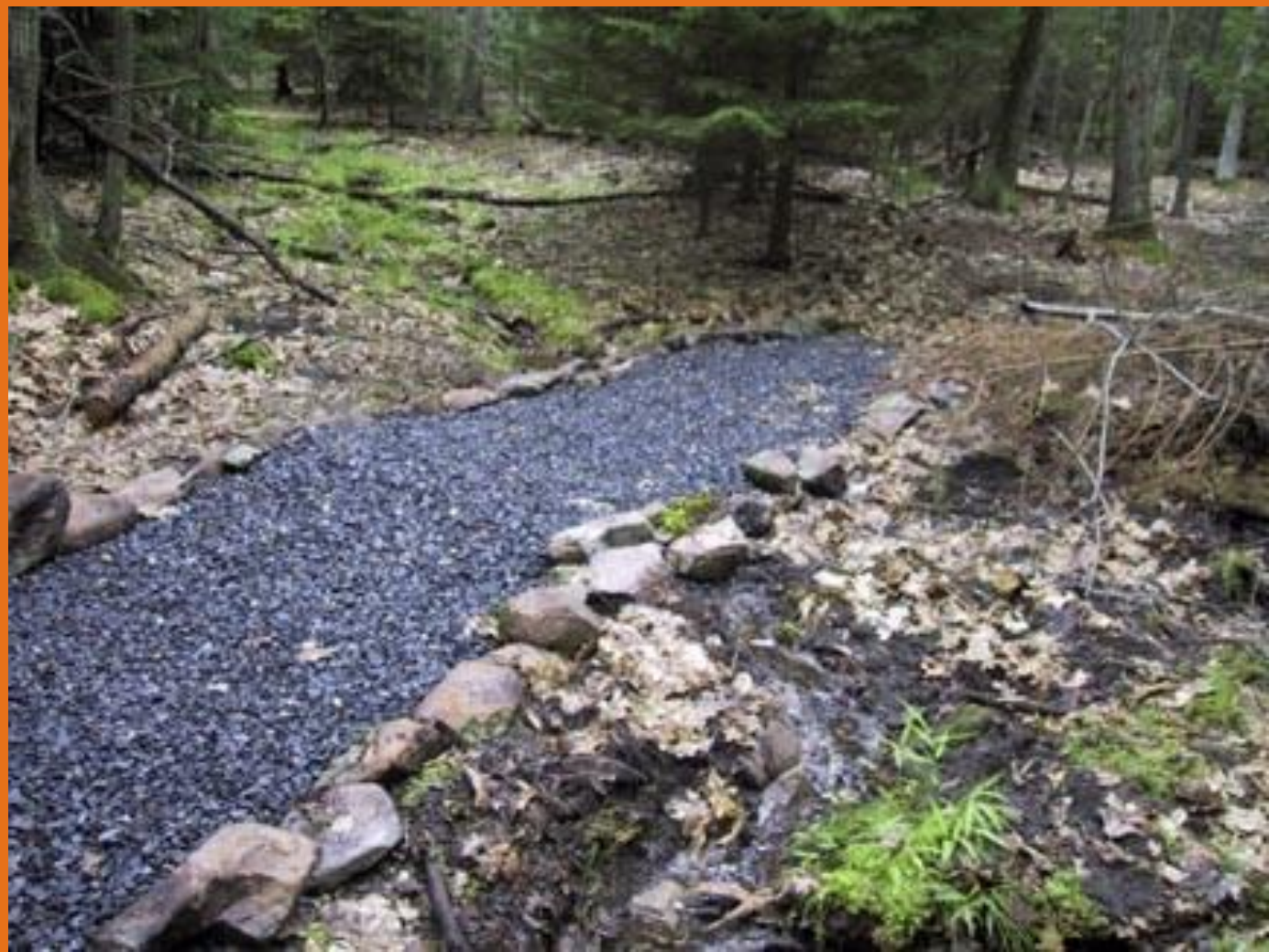
- Used on Saturated Trails Bisected by an Ephemeral Spring or Seep.

- Used Where Saturated Soils Create Muddy Unstable Tread



Drainage Lenses

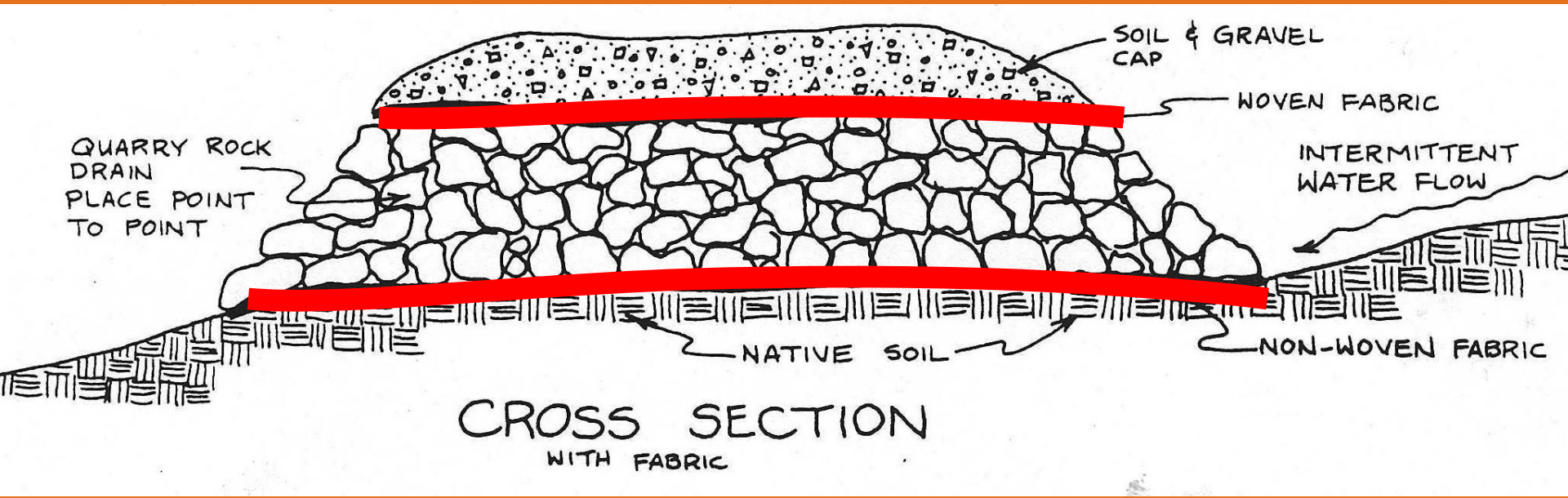
- Used on Saturated Trails Bisected by an Ephemeral Spring or Seep.



- Used Where Saturated Soils Create Muddy Unstable Tread

Drainage Lenses

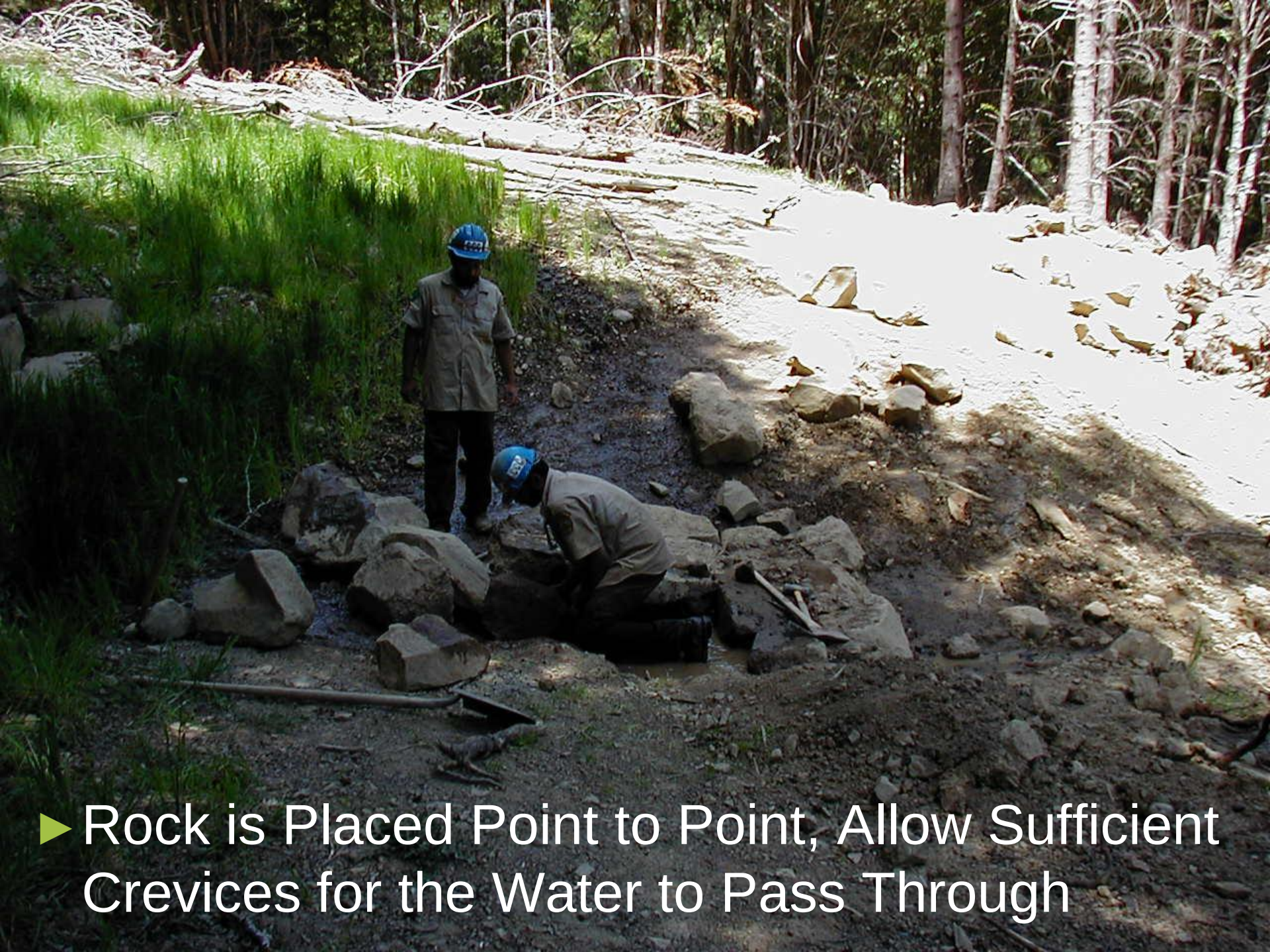
- Use of Geotextiles is Recommended
- Sandwich the Rock Lens Between Two Layers of Geotextile Fabric
- Stable Base is Established, the Rock is Protected from Contamination or Plugging with Saturated Soils



Construction of a Drainage Lens

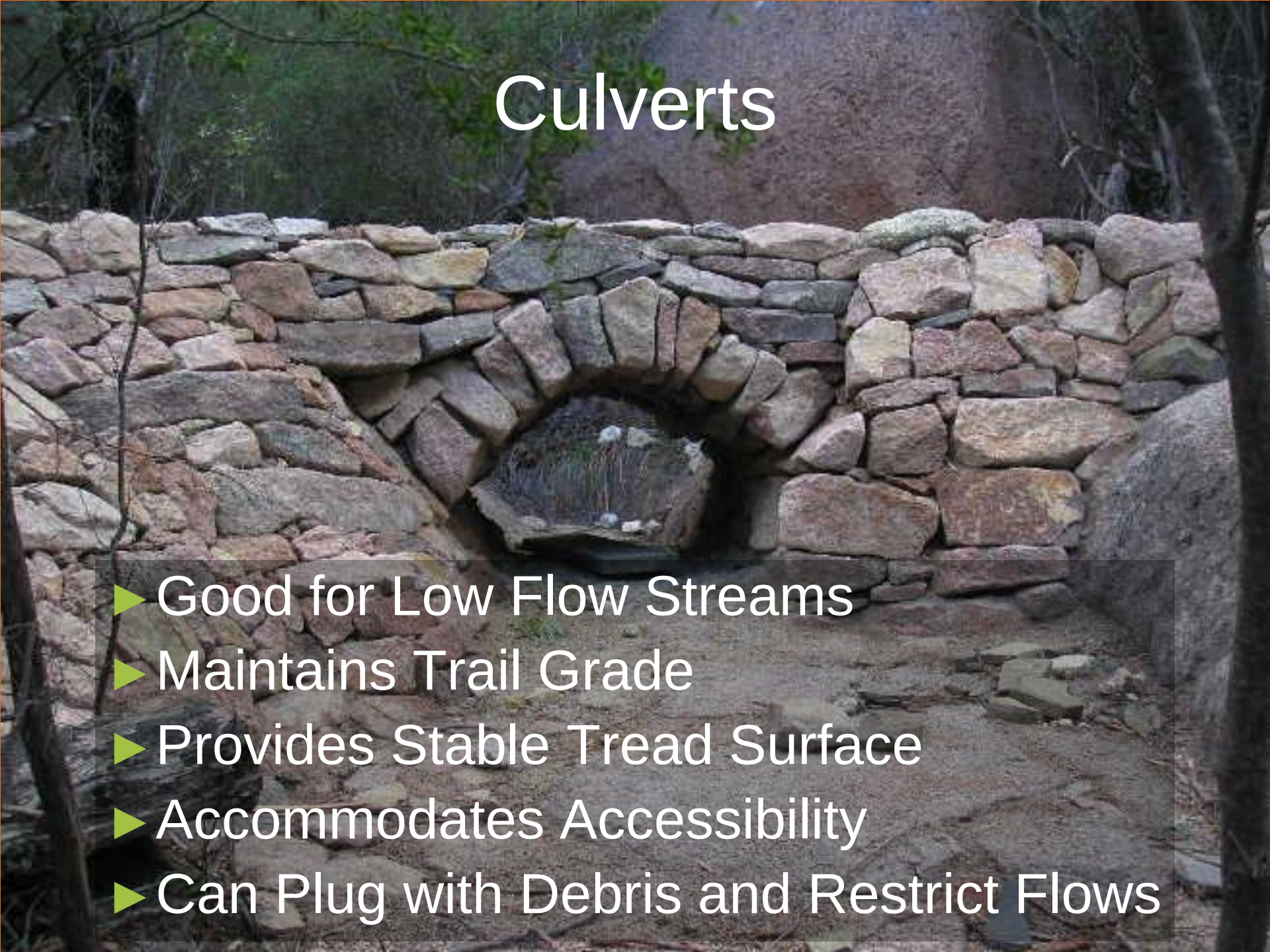
Saturated Trail Bed is Fully Excavated

- Void is filled with Large Angular Quarry Rock
- The Bottom Course is the Largest Quarry Rock



- Rock is Placed Point to Point, Allow Sufficient Crevices for the Water to Pass Through

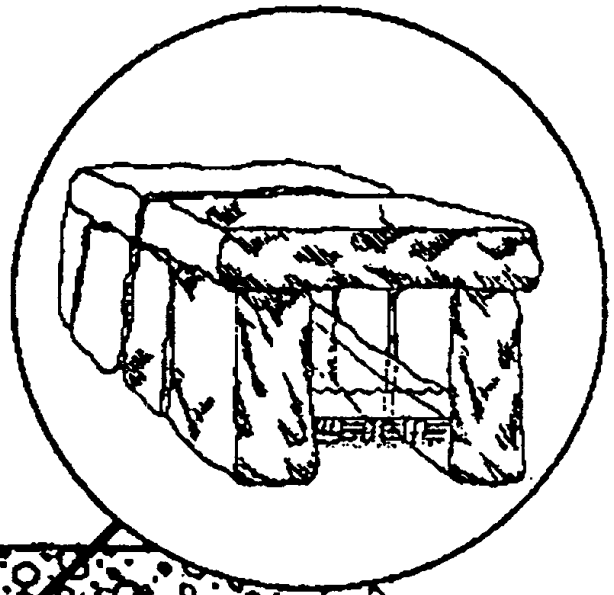
Culverts

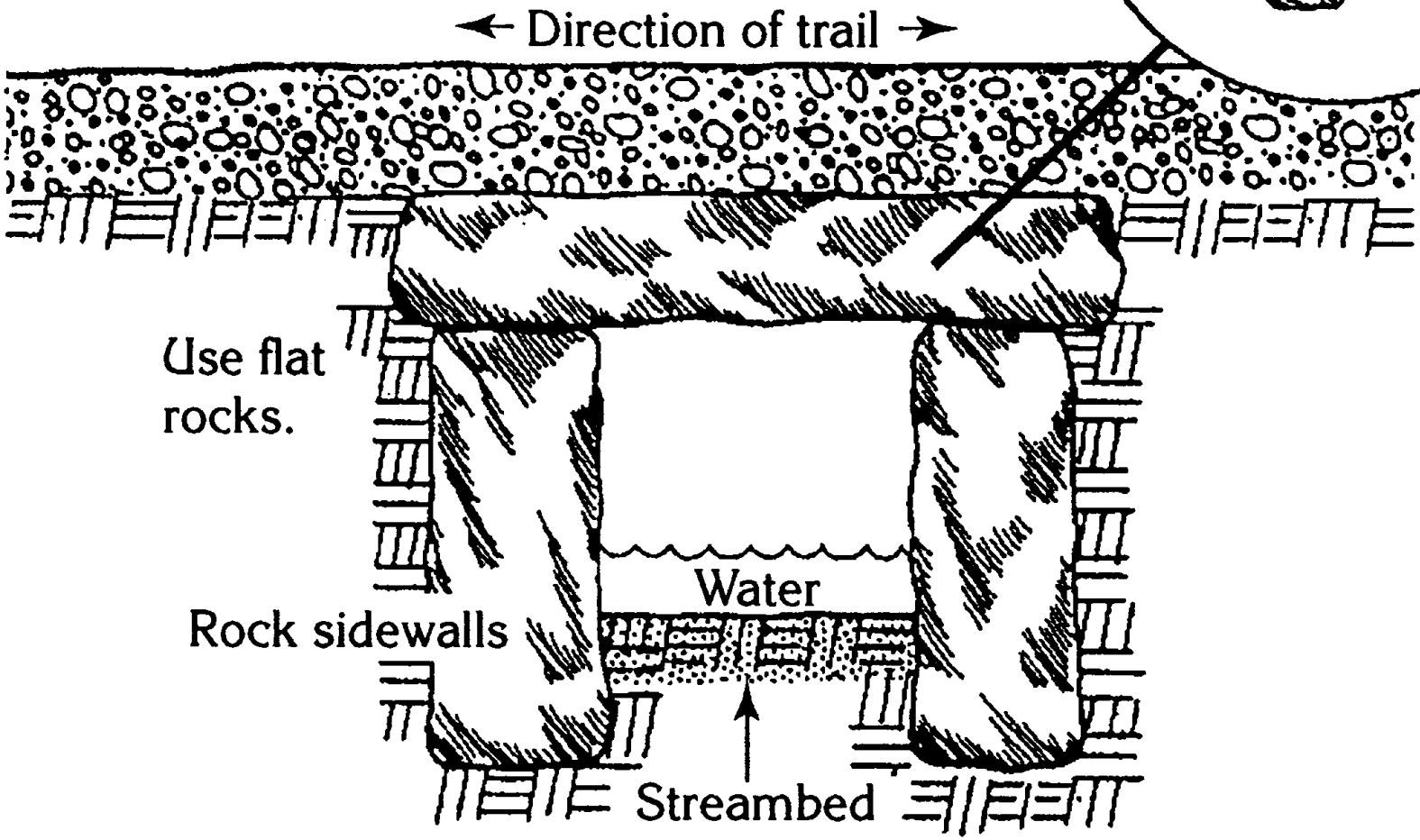


- Good for Low Flow Streams
- Maintains Trail Grade
- Provides Stable Tread Surface
- Accommodates Accessibility
- Can Plug with Debris and Restrict Flows

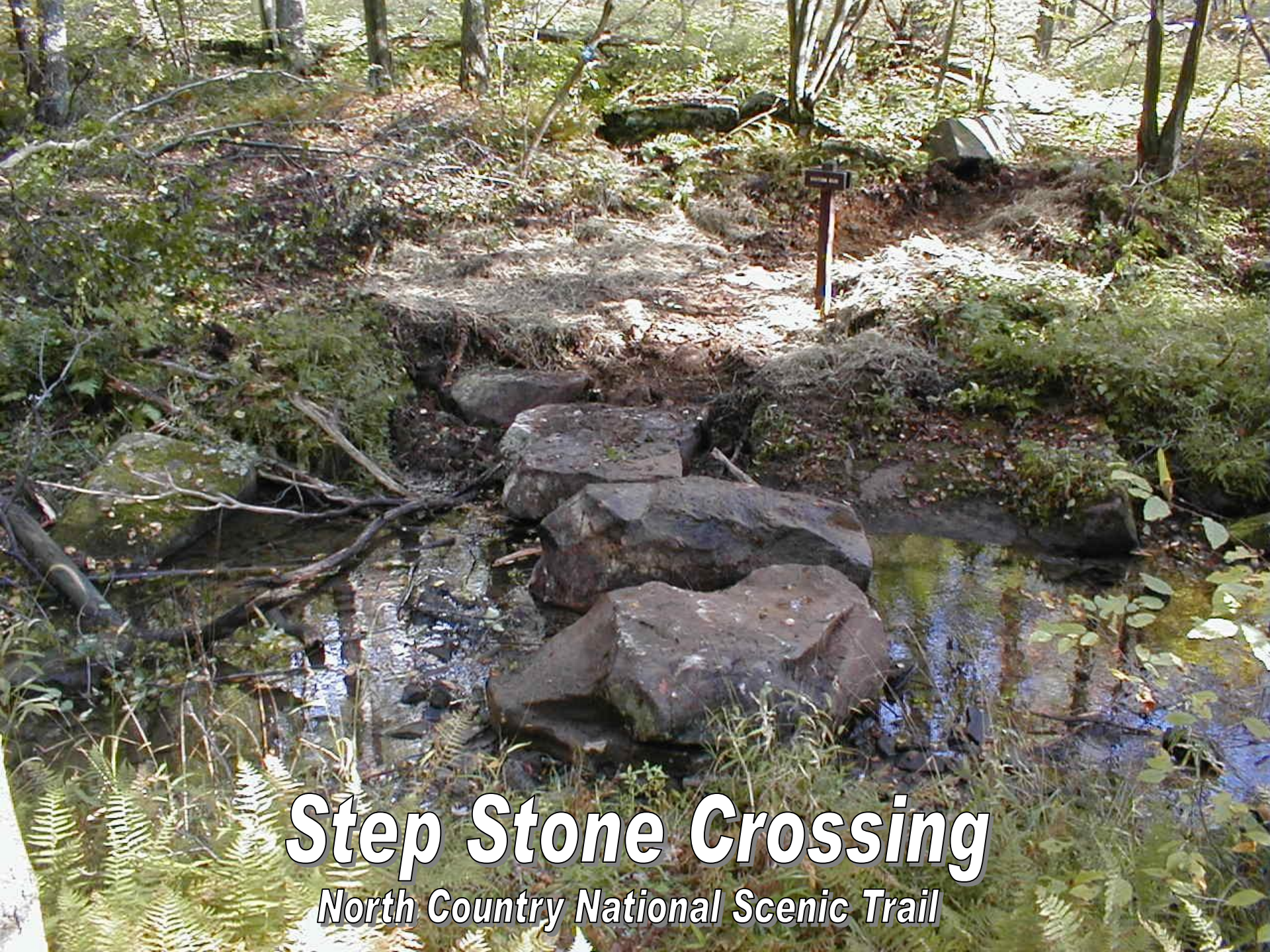
Types of Culverts

Rock Culvert






Squash CMP Culvert


Step Stone Crossing
North Country National Scenic Trail

Good for Low to Moderate Flows

Fair Crossing for Experienced Hikers

Can Obstruct the Stream Channel and is Not Accessible

Step Stone Crossing

Trail Tread Structures

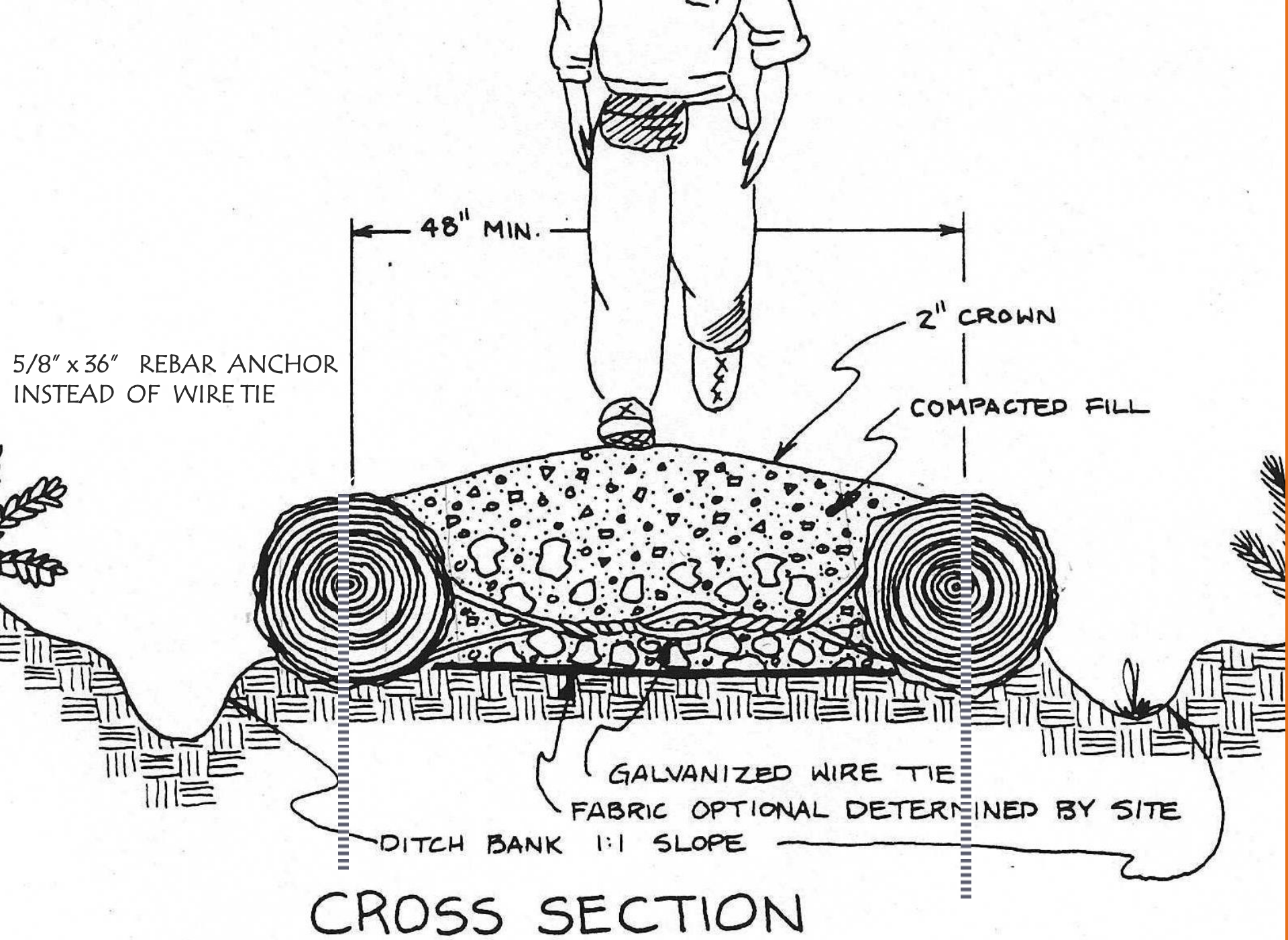
- Turnpikes and Causeways
- Corduroy
- Gravel Surfacing
- Hardened Tread - Rip Rap, Pavers; Synthetic and Masonry
- Trail Steps

KK


Turnpikes, Causeways and Corduroy
Sugar Pine Point
State Park Lake Tahoe

Turnpikes

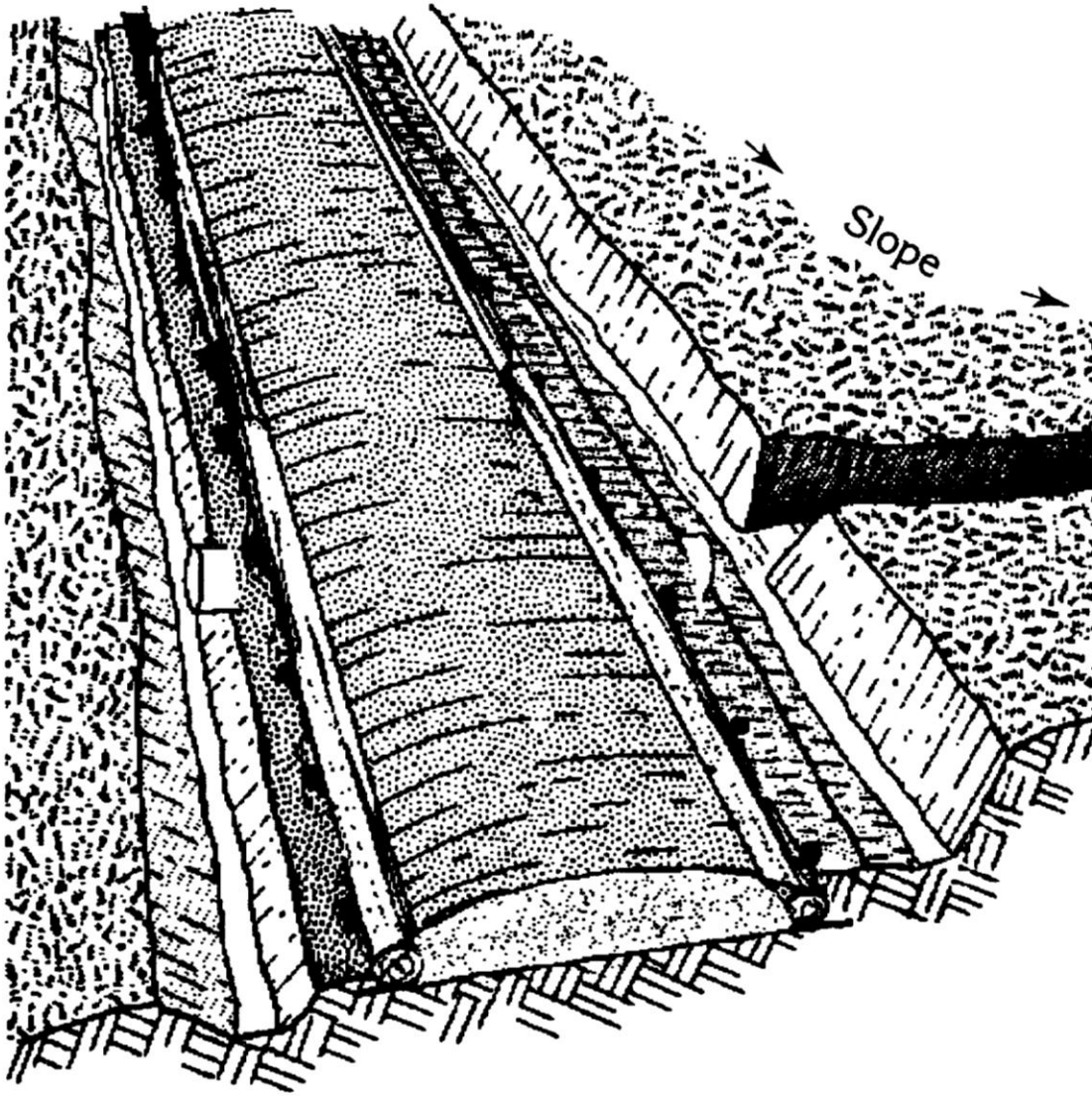
- Turnpiking is the Process of Hardening the Trail by Raising the Tread Surface Above the Ground through Boggy, Wet or Muddy Areas
- It Consists of Two Curb Logs, Placed Parallel to the Trail, filled with Rock, Gravel or Soil, then Crowned
- A more Permanent Structure
  - Preferred over Puncheon when Material and Work Force are Available



CROSS SECTION

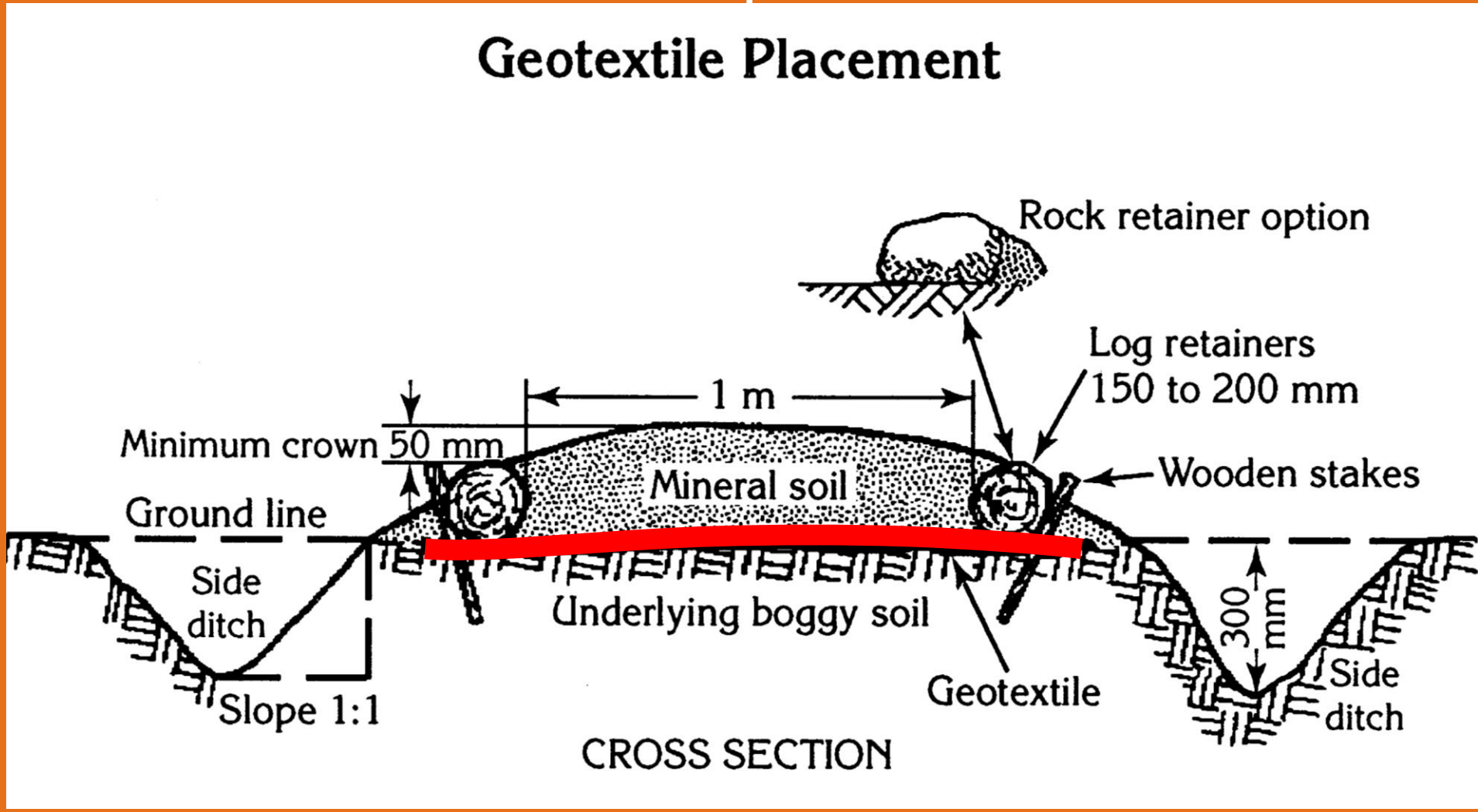
Turnpikes
Ditch and Elevate

- Water can be Collected and Channeled by Parallel Ditches
- Drain Lenses or Culverts Carry the Flow Under the Turnpike and Drain Down slope



Turnpikes

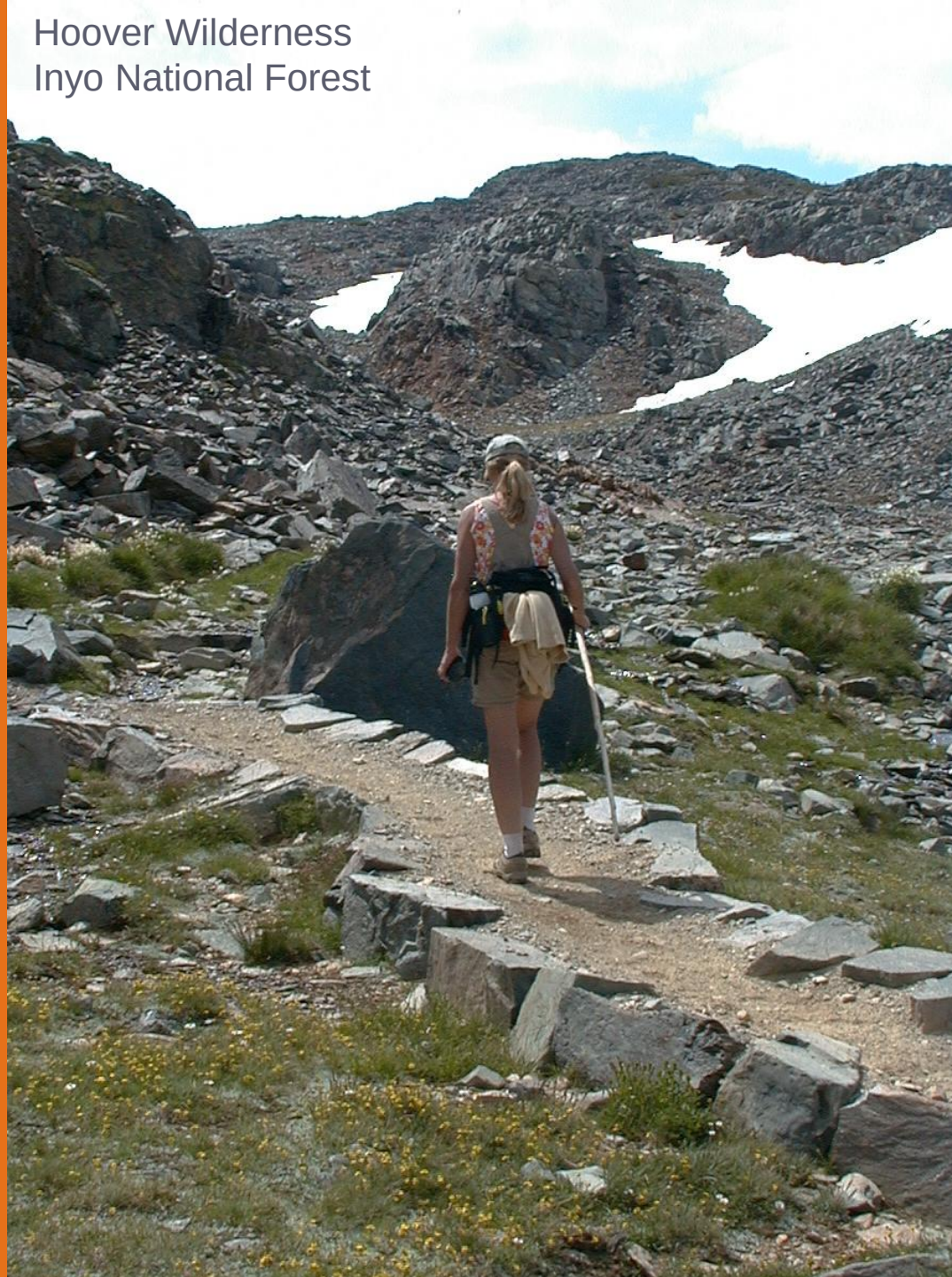
If the Soils are Boggy or Saturated – Geotextiles can Float Turnpike Materials



Causeways

Rock Causeway

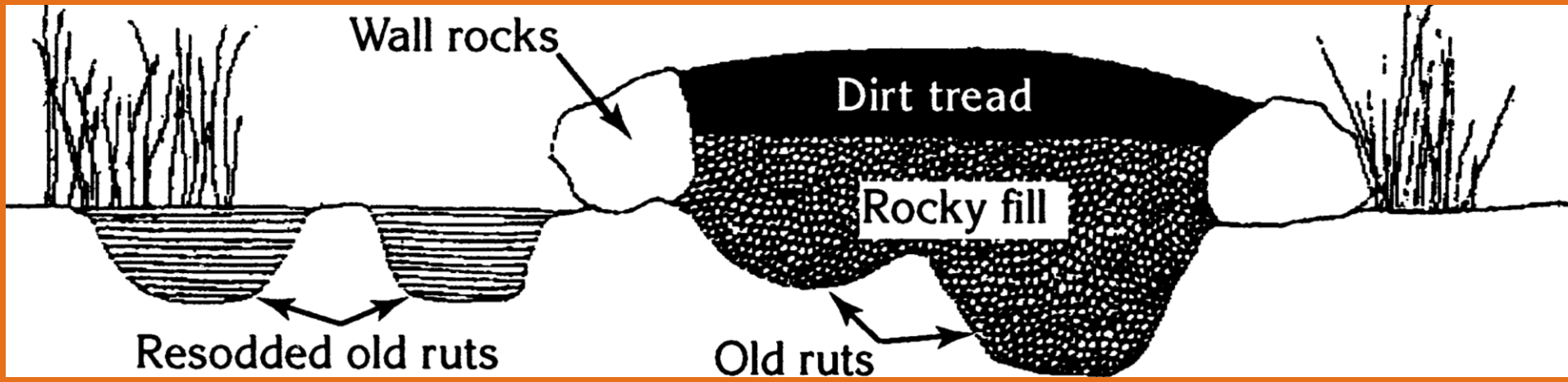
- Elevated Section of Trail
- Trail Tread Contained by Rock
- Bridges Permanent or Seasonally Wet Areas.




Causeways are Typically Filled with “Crush”
or Larger Angular Rock For Drainage

Causeways

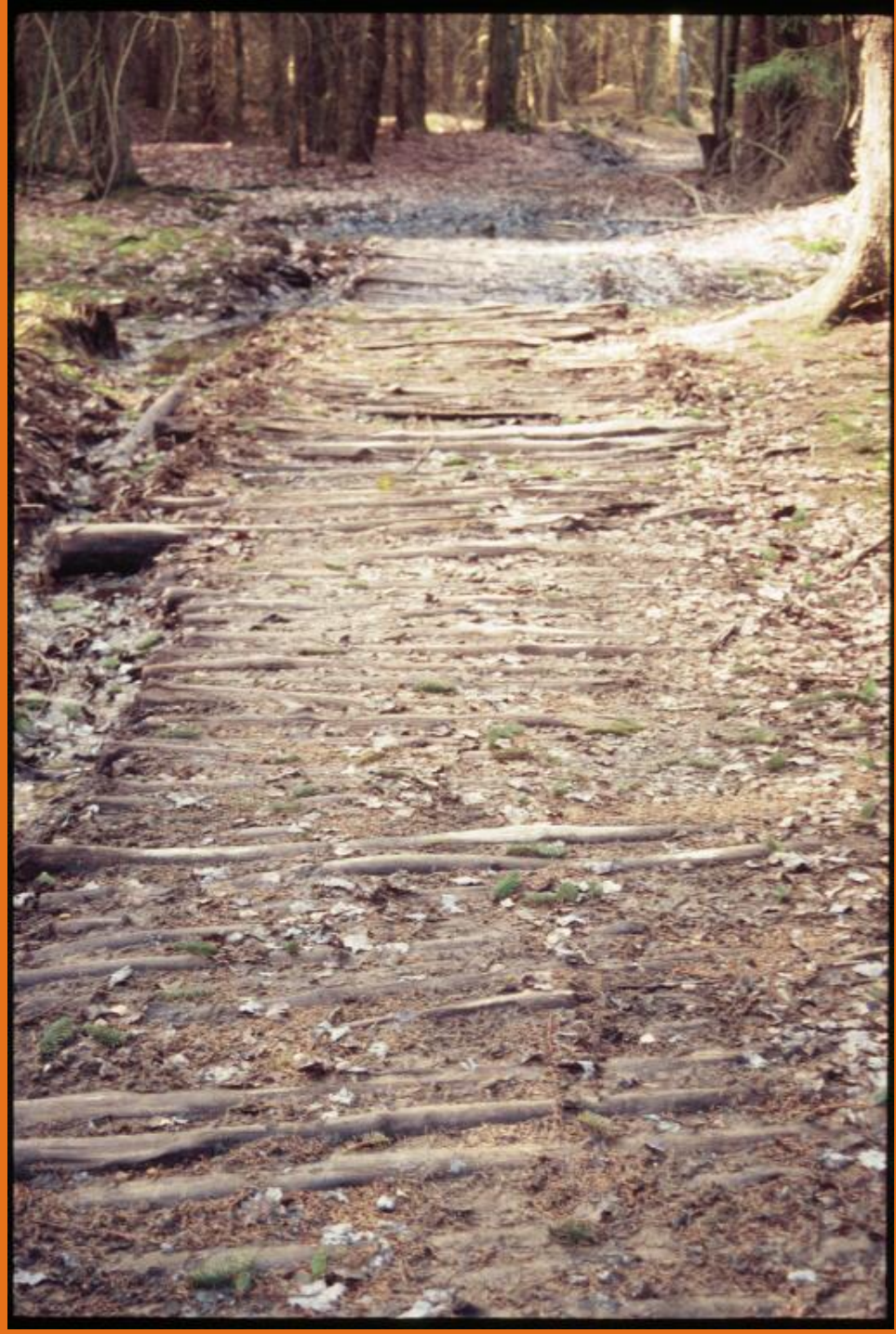
- Causeways can be Used to Consolidate Areas of Multiple Trail Ruts into One Trail and Allow Re-vegetation



- A Causeway is Built to be as Inconspicuous as Possible. Do not Over Build, Design Close to the Minimum Height and Length Needed to Cross the Problem Area.

Corduroy

- Laying of Horizontal Small Logs in Boggy Areas
- High Resource Impacts
- Temporary fix
- Will Only Last if Logs are Saturated Year Round

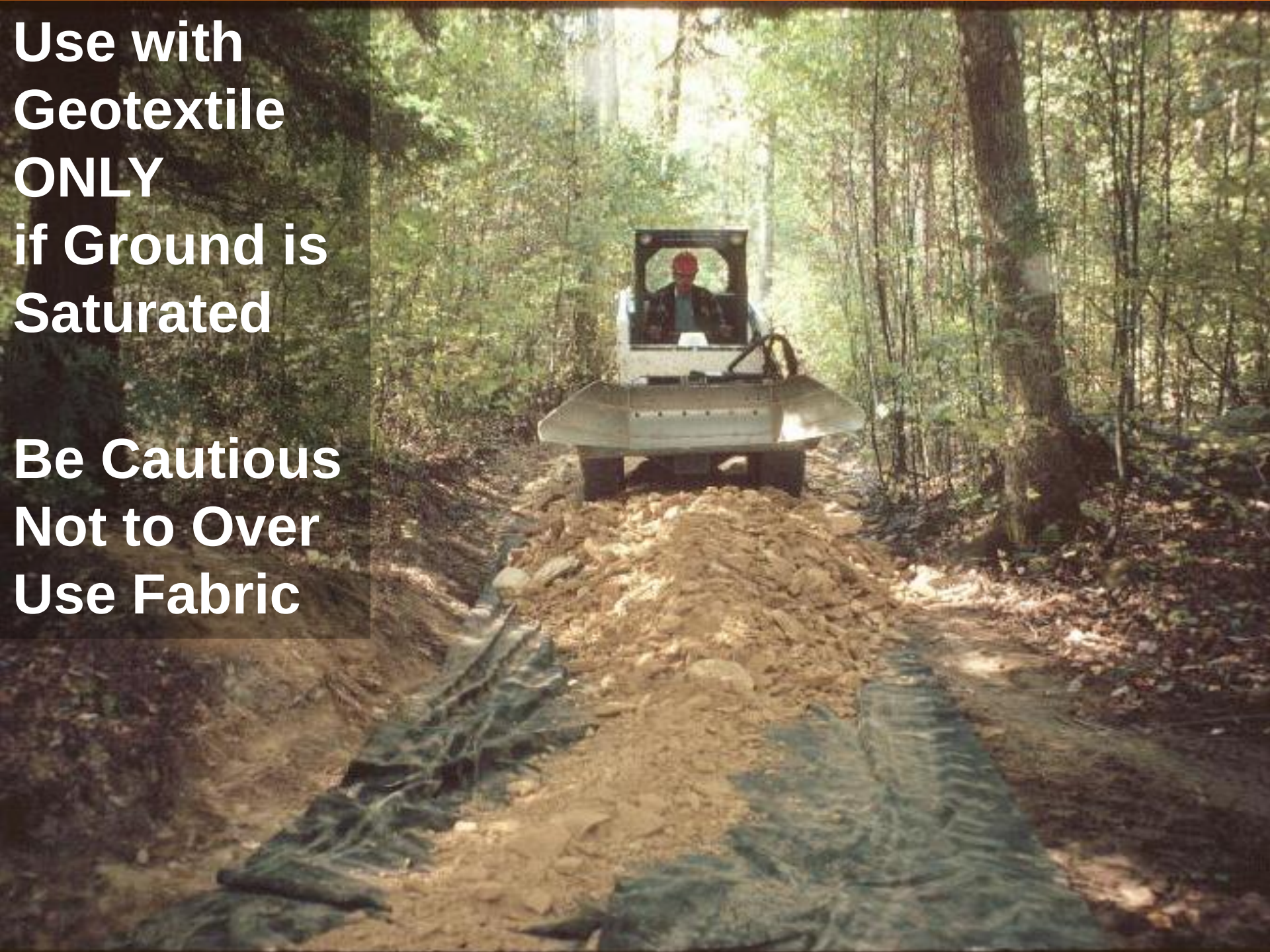


Gravel Surfacing

Gravel Surfacing

- Gravel Provides a Hardened Maintainable Tread for Horse, OHV, Mountain Bike or Accessible Users
- The Trail Tread shall be Crowned Where Cross Slope is at or Near 0%. Outsloped on Sidehill Construction
- Trail Tread Subsurface Grades shall be Prepared to Appropriate Drainage Design before Surfacing Placement
- Laying Gravel is Labor and Equipment Intensive


Aggregate for Surfacing:
•Needs Matrix of Sizes
•Mixture of Clays, Silts, Fines
•Fractured Faces
For Good Compaction
6/12/2001 11:31am


Use with
Geotextile
ONLY
if Ground is
Saturated
Be Cautious
Not to Over
Use Fabric


Compaction is Critical
Proper Moisture Content is Required
3141
DYNAPAC
Grand Canyon National Park

Fix the Alignment
Before Surfacing

Otherwise……..
the Problem will Return

Trail Hardening with Pavers

- Hardening to Protect Low Capability Soils and Tread from Aggressive User Types
- Labor Intensive
- Must Be Placed Appropriately for Aesthetics
- Tread Specifications Are User Type Dependent


Level the Surface


"Grout" or Fill Blocks


Can be Used to Harden
Superelevate Curves for Tread Protection

Geosynthetics Tread Stabilization

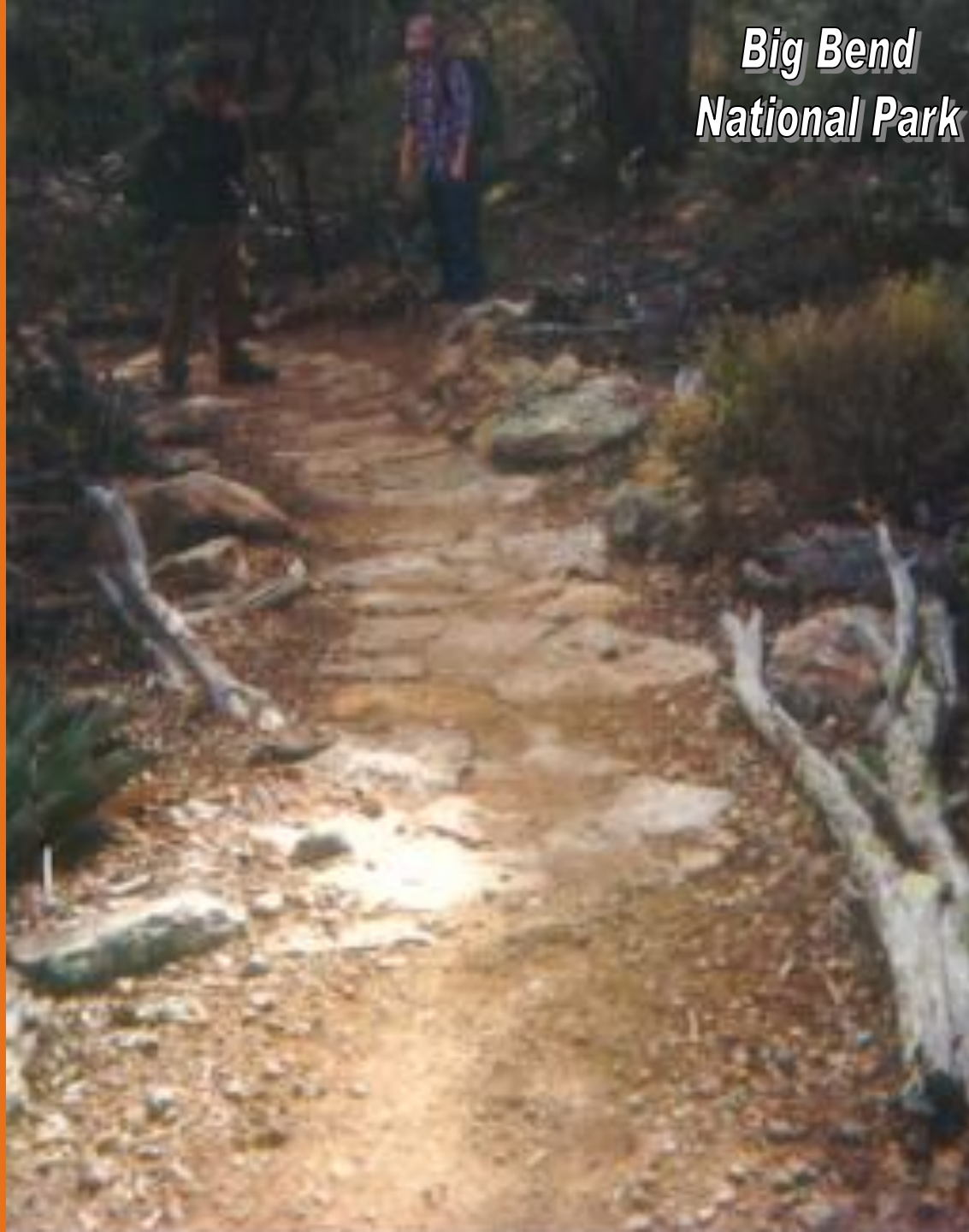
http://www.nps.gov/akso/riversandtrails/trailpubs.htm


Alaska

Be Sensitive to Gravel Harvesting Site Damage

Trail RipRap

- Stone Placed Tread Surfacing
- Like Cobblestone Pavement
- Used Primarily on Primitive Earth Mountain Trails
- High Skill Level Needed



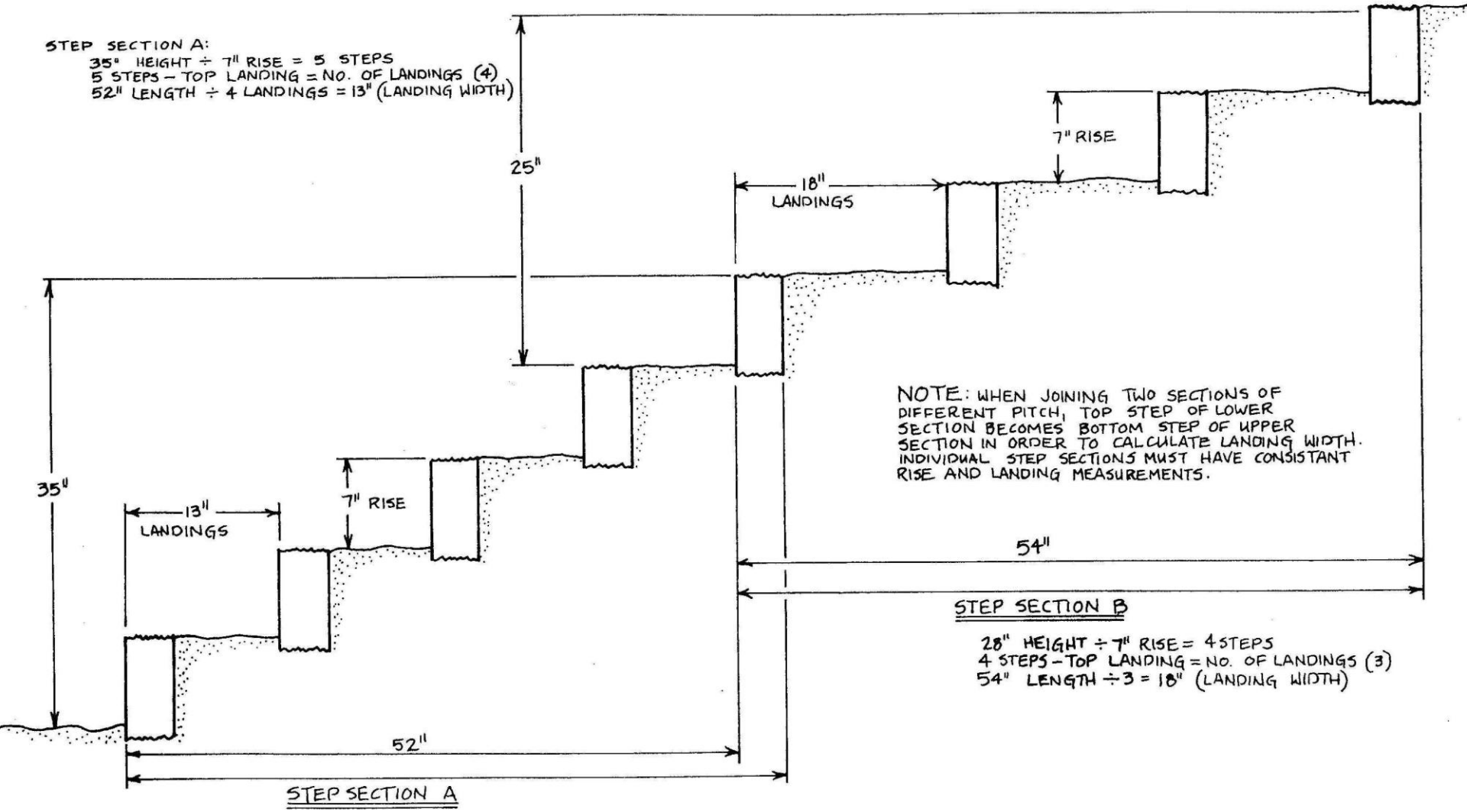

Stabilizers, Hardeners and Concretes

- Soil Stabilizers: Pine Resin, Enzymes, Sulfuric Acid, Polymers, Ground Seed Hulls, Clay, Fly Ash, Asphalt and Cement Concretes
- Used in Trail Surfacing Requiring Firm and Stable Surfaces


Accessible
High Use
"Cold Patch Asphalt"

Trail Steps

- Trail Steps are Used for Rapid Elevation Gain in Steep and/or Low Soil Capability Trail Tread
- Steps are Designed and Placed at Proper Locations
- Steps should be Thoughtfully Placed on the Trail to Ensure that Hikers will Use them
  - They have to have Evenly Spaced Rise and Run, otherwise they will be avoided by hikers

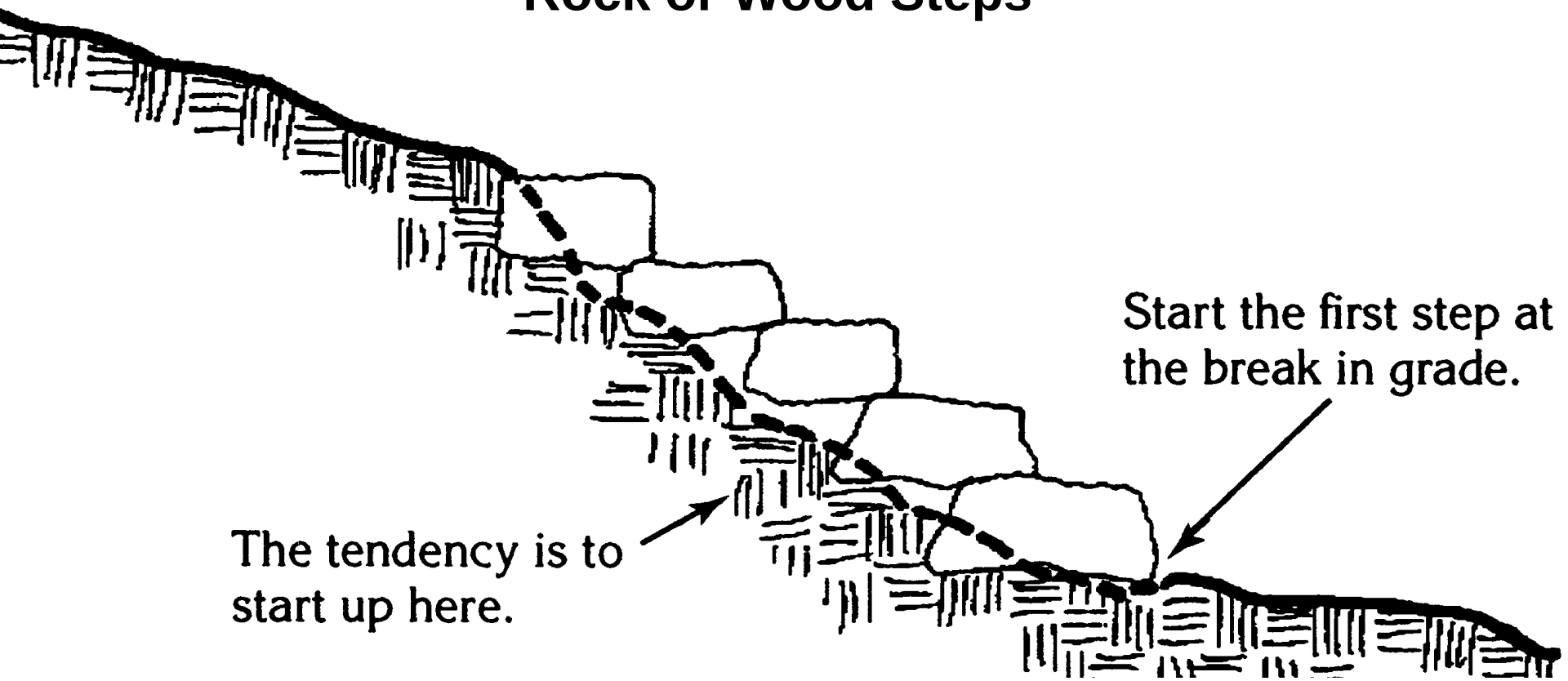


STEP CALCULATIONS

SCALE: 1"=1'-0"

Typical Step Installation

Rock or Wood Steps

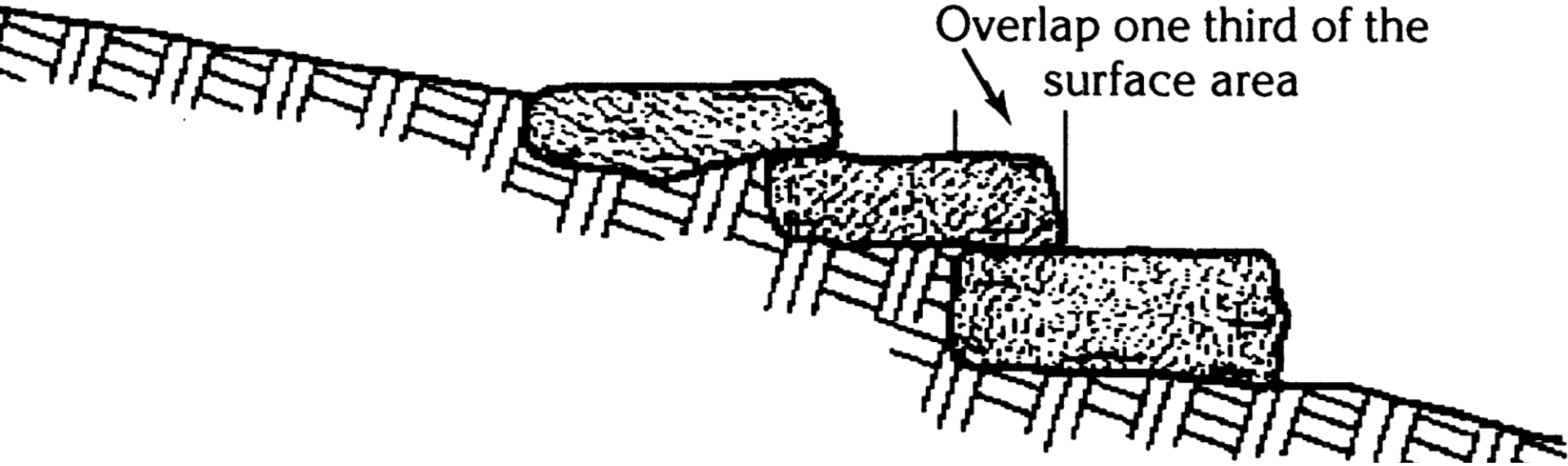


- Work up from the Bottom of a Slope.
- Makes it Easier to Determine Best Placement and the Optimum Mix of Stabilization Techniques

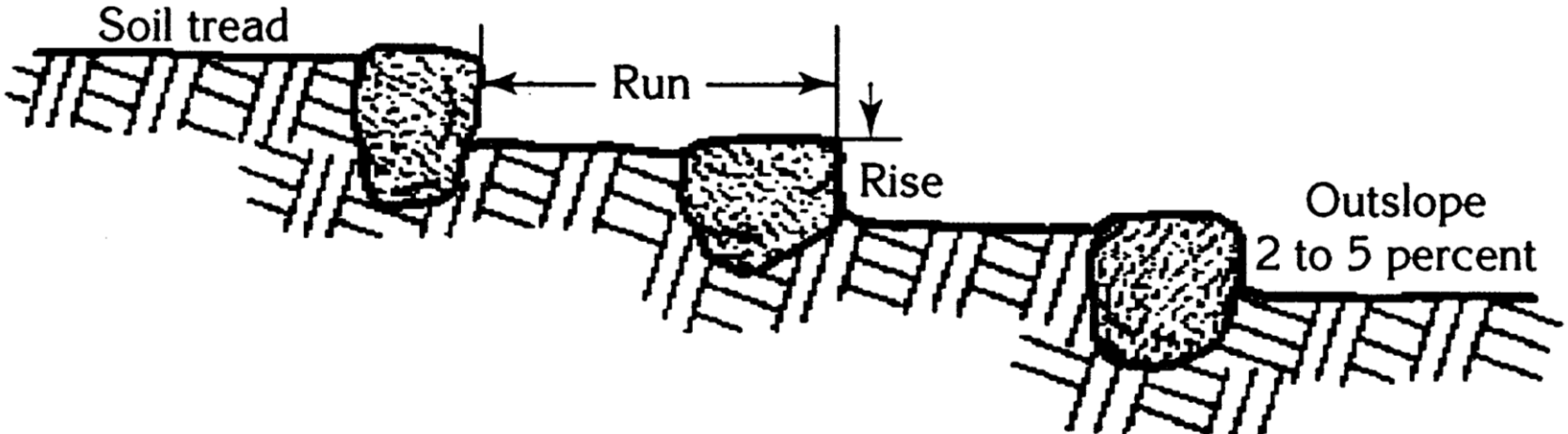
Rock Steps

- If the Setting is Appropriate, Rock Steps are Aesthetically Pleasing and will Last Longer than Wood Steps
- Suitable Rock may not be Readily Available in Some Locations. Additional Effort Required to Transport Rock may be Justified.
- Rocks should be at least 100 pounds and Span as much of the Tread Surface as Possible
- High Skill Level for Quality Rock Steps

Overlapping Rock Stairway



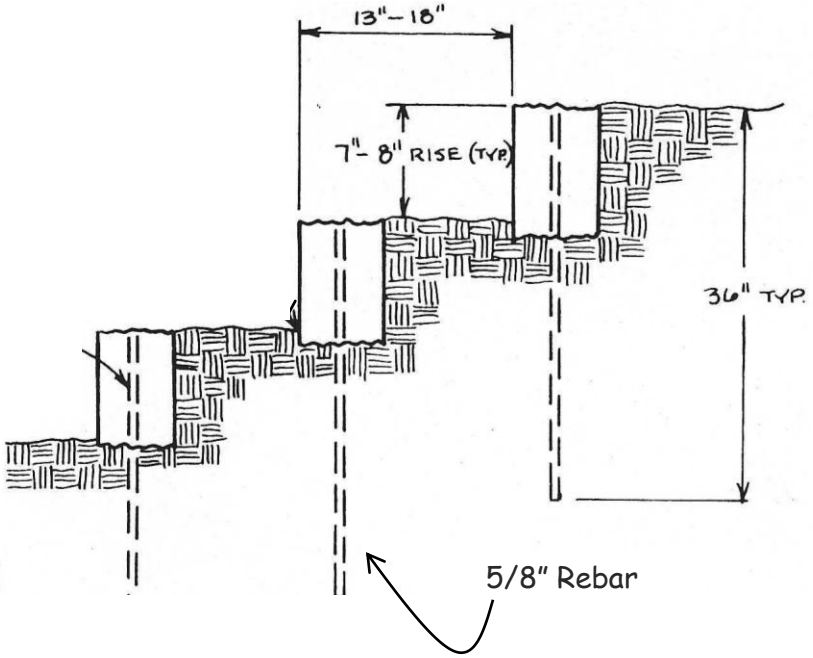
Rock Riser Stairway

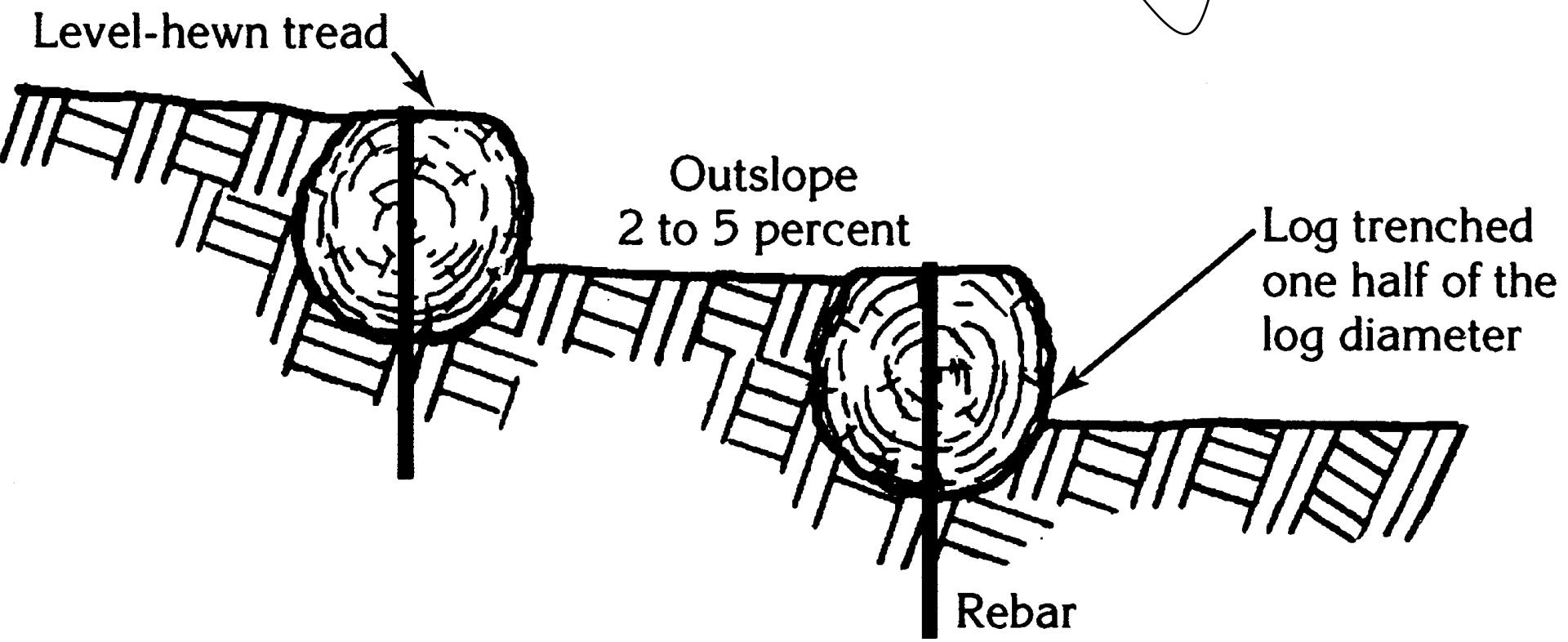


Log and Wood Steps

- Skill Level to Install is Lower
- Designed The Same as any Step Carriage

Wood Step Installation



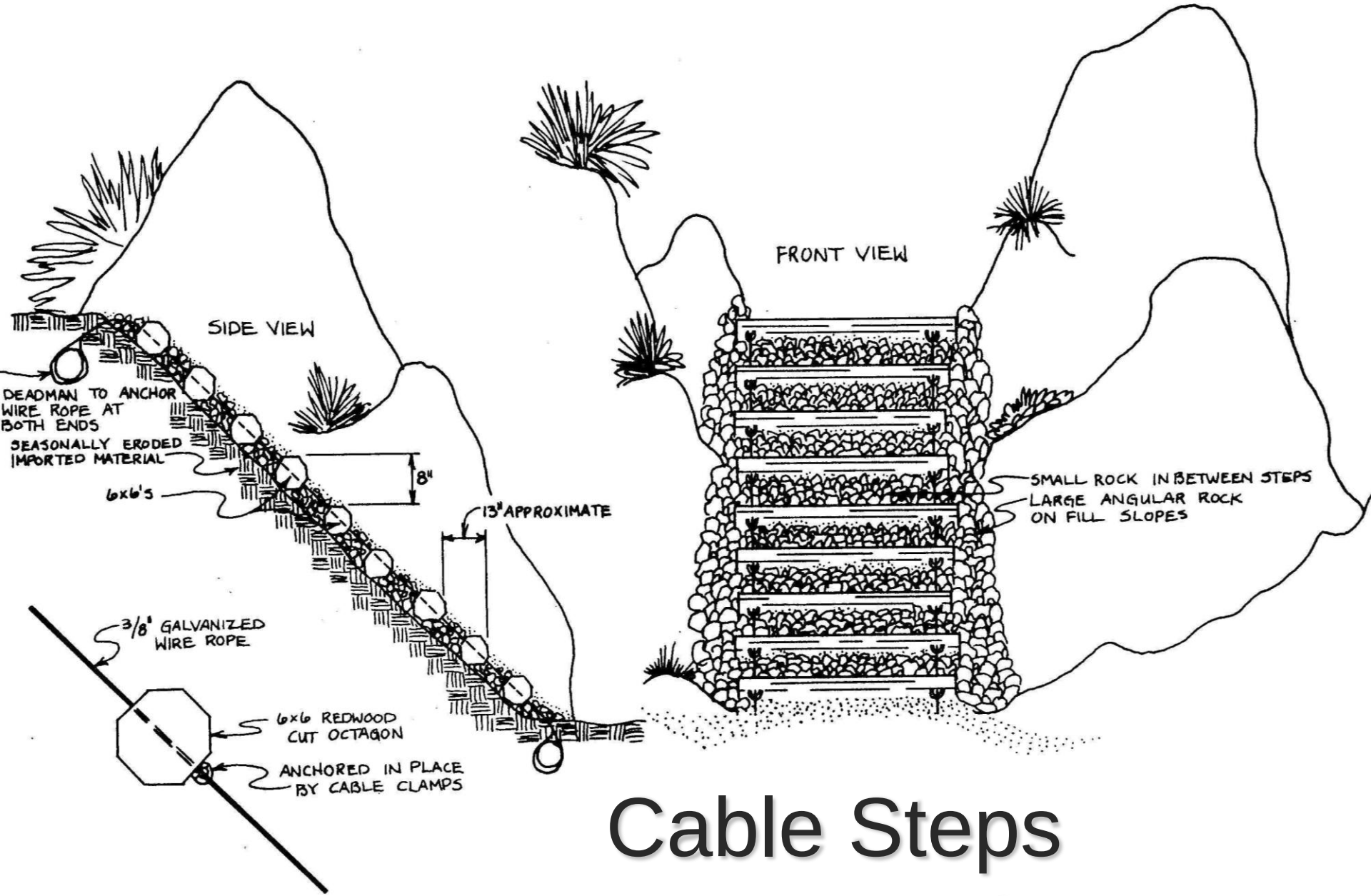


"Constructed Stair Cases"

Kachemak Bay State Park
Homer Alaska

Cable Steps

- Steps that are Draped over a Surface of Highly Erodible Material such as Sand or Seasonally Flooded Areas -- Ocean Bluffs or River Access
- Rise and Run of the Step Section Determined by the Slope of the Hillside
- Some Locations may Require Importing Suitable Material Beneath the Step Section so a Reasonable Rise and Run is Obtained


SIDE VIEW
FRONT VIEW
DEADMAN TO ANCHOR WIRE ROPE AT BOTH ENDS
SEASONALLY ERODED IMPORTED MATERIAL
6x6's
8"
13" APPROXIMATE
3/8" GALVANIZED WIRE ROPE
6x6 REDWOOD CUT OCTAGON
ANCHORED IN PLACE BY CABLE CLAMPS
SMALL ROCK IN BETWEEN STEPS
LARGE ANGULAR ROCK ON FILL SLOPES

Cable Steps

Cable Steps

Octagonal Timbers or Peeler Cores

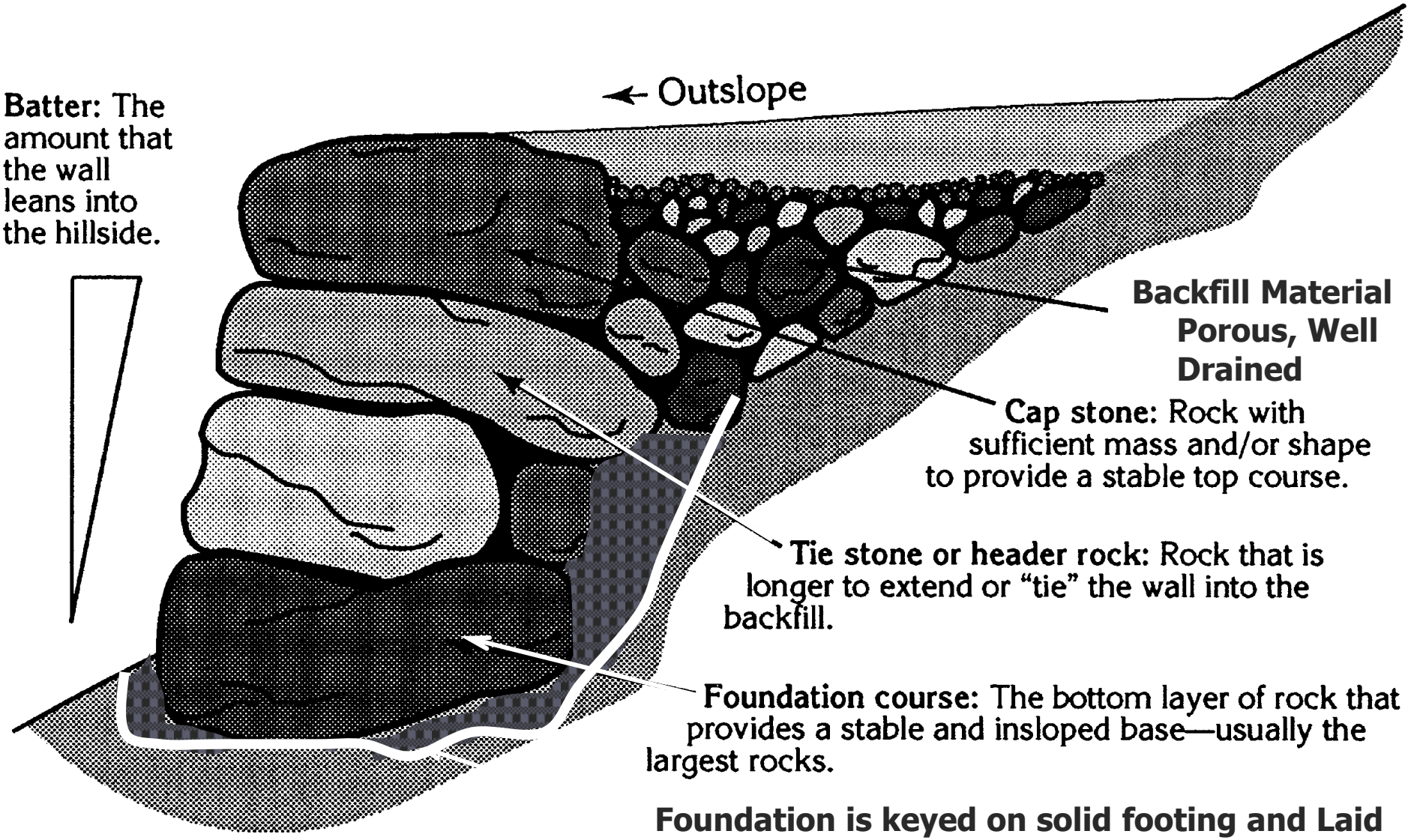
Clamps Below Timbers

Anchor Cables at Top and Bottom

Retaining Walls

- Retaining Walls Basics

Crib Wall Terminology



Types of Retaining Walls


Pinnacles
National Monument
Rock Wall

Wood Crib Wall

"Celluar Confinement"

Gabion Retaining Wall

Mortored Wall

Scuptured Concrete Wall

Soldier Pile Wall

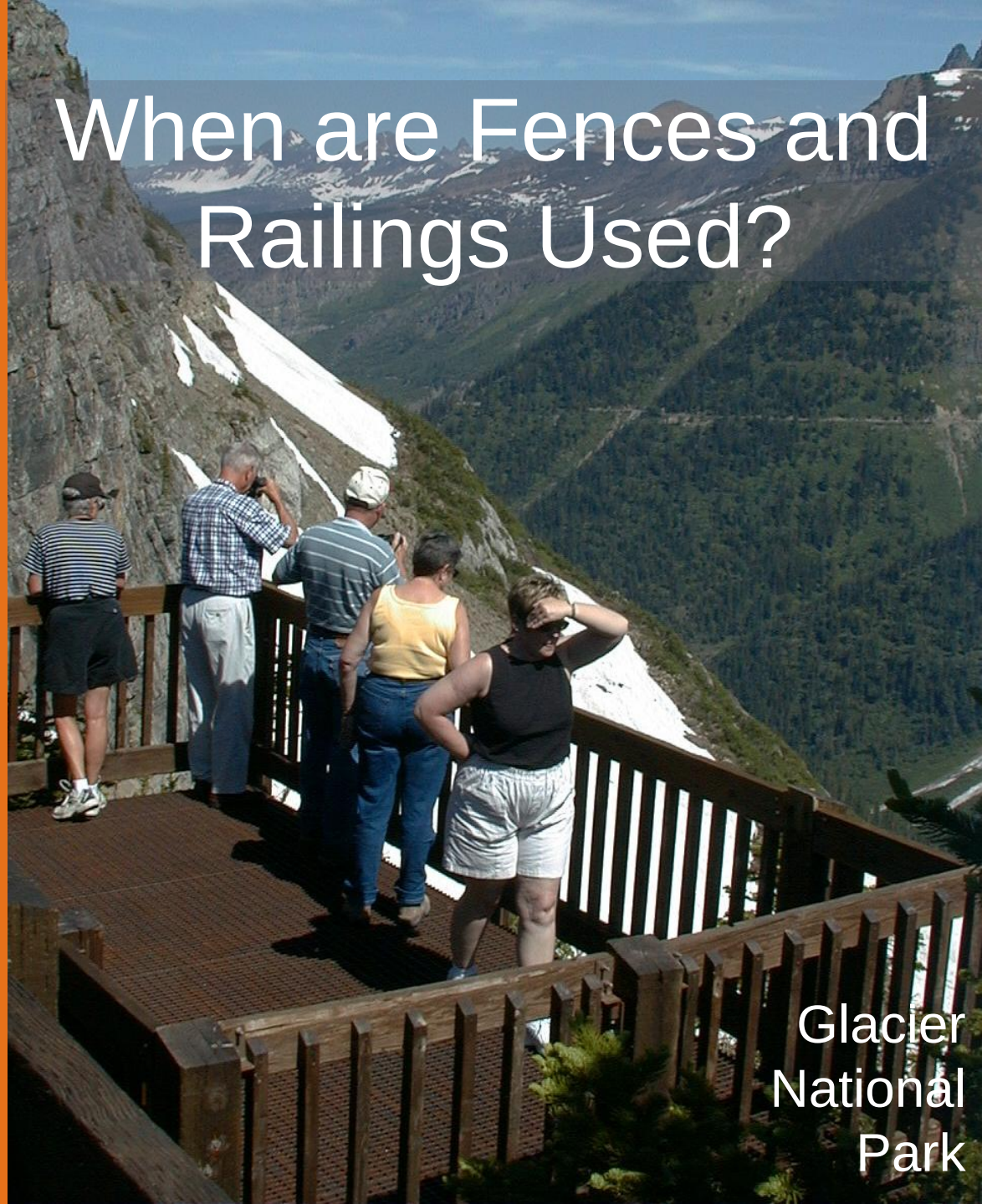

Geotextile Fabric
Retaining Wall

Retaining Wall Design Review

- Provide a Solid and Level Foundation with a 3% Set Back
- Higher Walls may Require a Batter
- Anchors are Needed to Transfer Weight to the Rear of the Wall
- Provide for Drainage to Reduce Pore Pressure

Fences and Railings

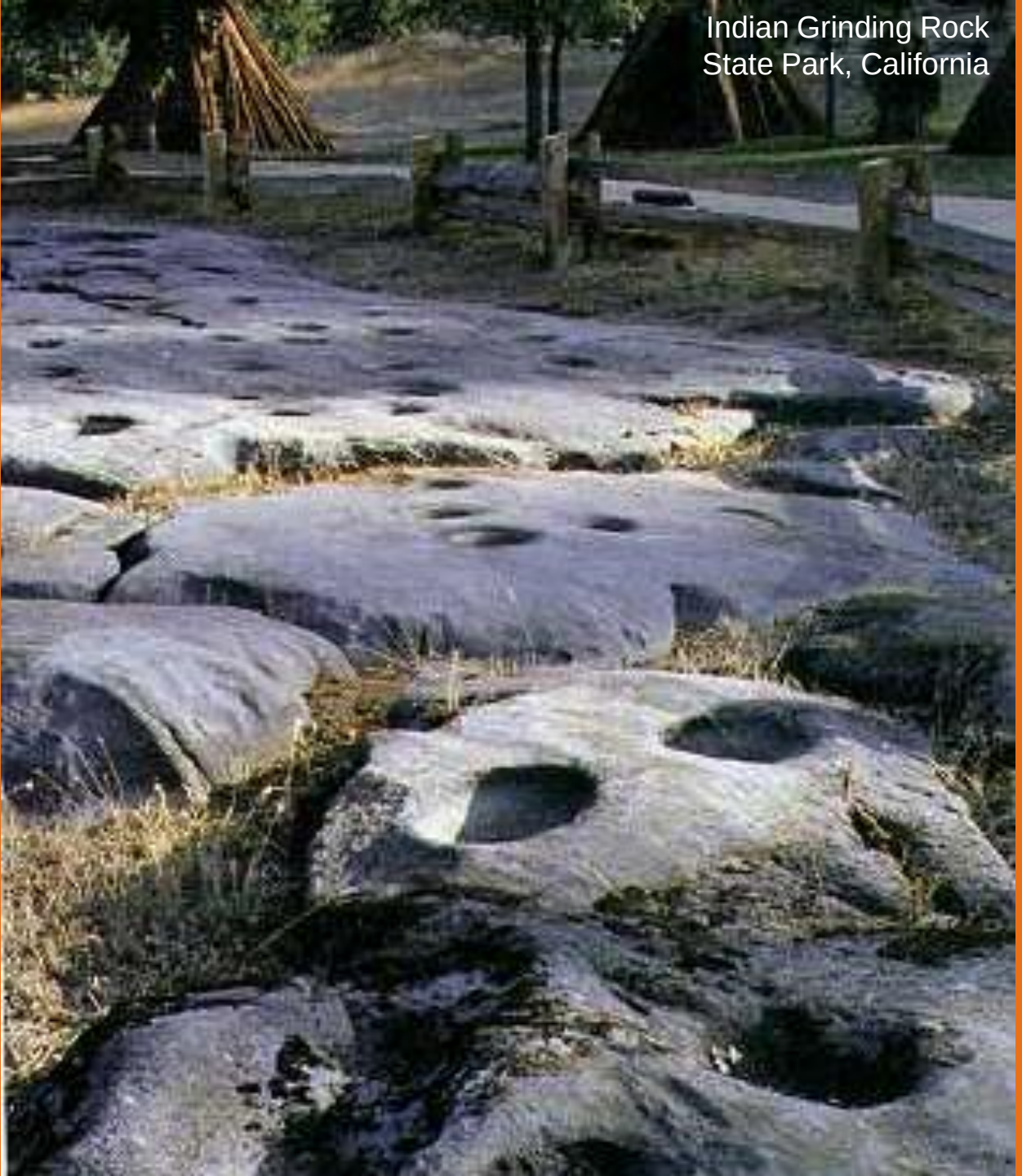
When are Fences and Railings Used?



Glacier National Park

Protect Users from Harm

Grand Canyon National Park


Indian Grinding Rock
State Park, California

Protect Sensitive Resources


Provide Direction in High Use Areas
Zion National Park

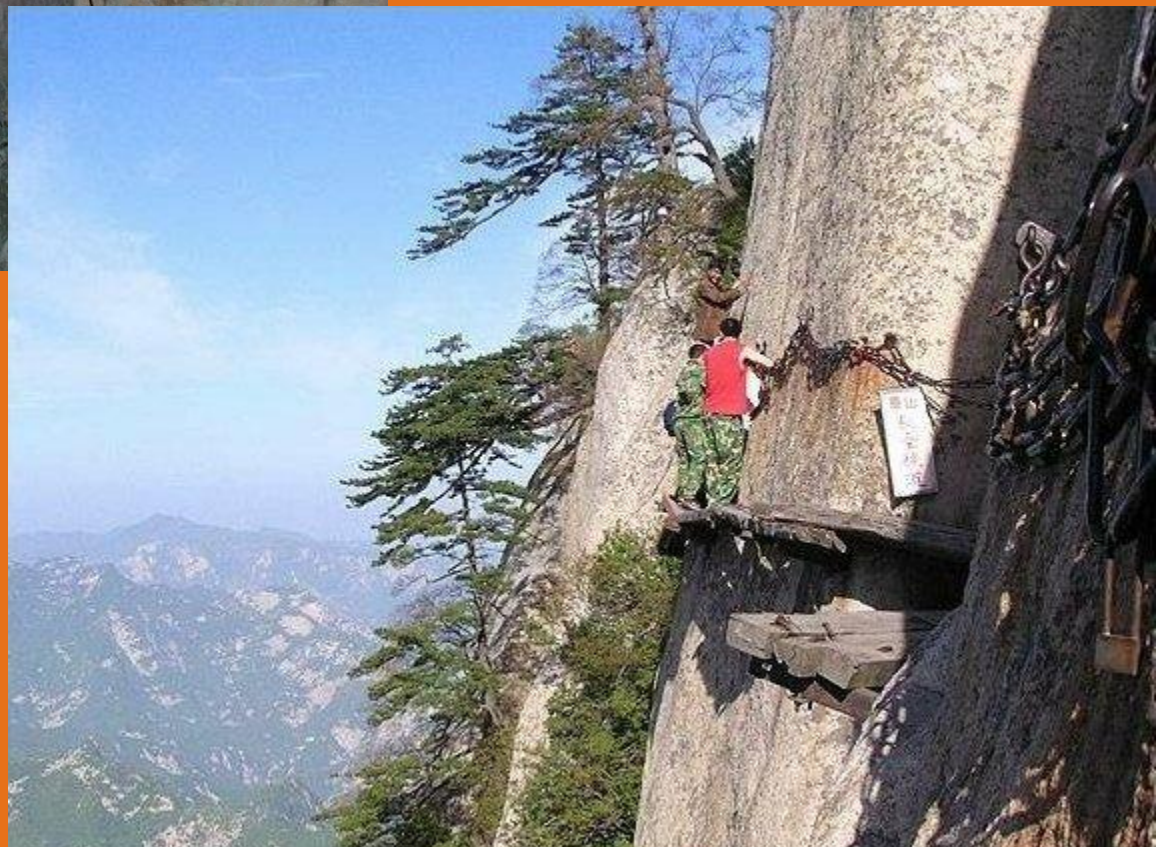
Focus Attention at Overlooks

Great Falls Virginia

C & O Canal National Park

Safe Handholds on Steep Rock Trails with Unsafe Tread

BLM Lands
St George
Utah



Pinnacles
National
Monument

Pipe Rails


Wood Railing
Plumas
Eureka State
Park
California


Timbers
Canyonlands National Park

Mortored Wall

Emerald Bay Lake Tahoe

Aesthetically Design Rails to Setting

Bridges, Puncheons and Boardwalks

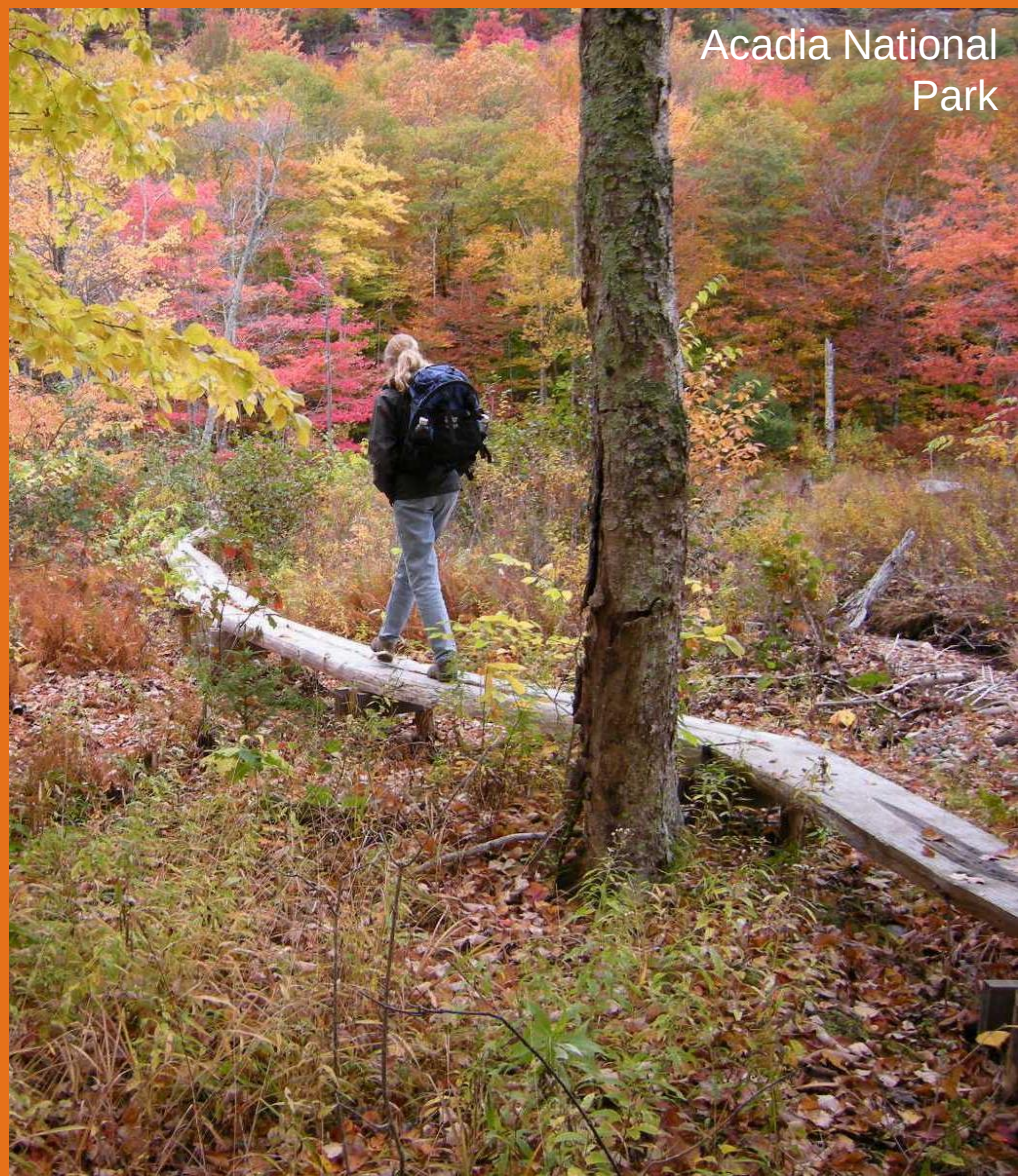
KK

Puncheons/Boardwalks

- Good for Low Flow Streams, Marshes
- Maintains Trail Grade
- Provides Stable, Accessible Tread

Planking

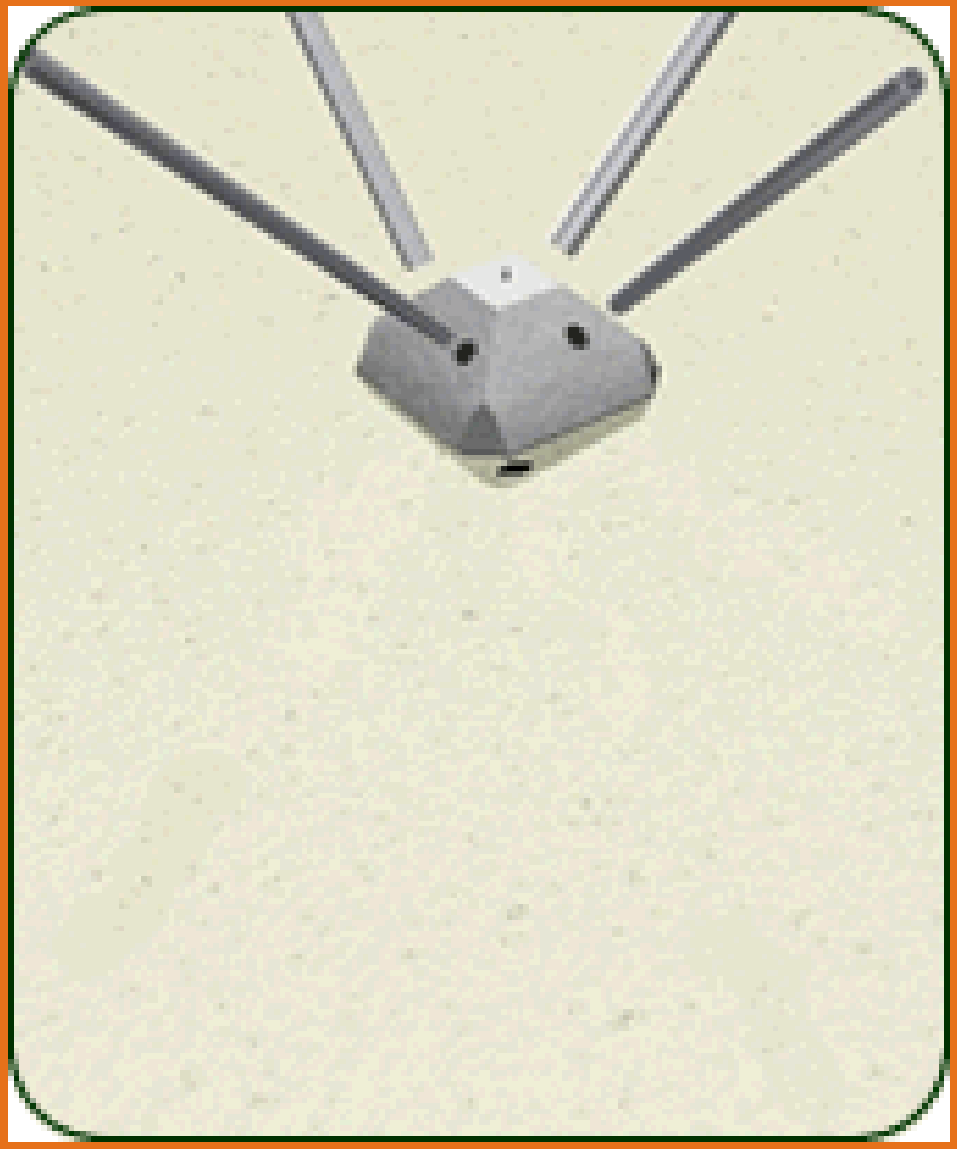

Point Bridget
State Park
Juneau, Alaska


Acadia National
Park

Helical Anchors

KK

Diamond Piers



KK

Diamond Piers

KK

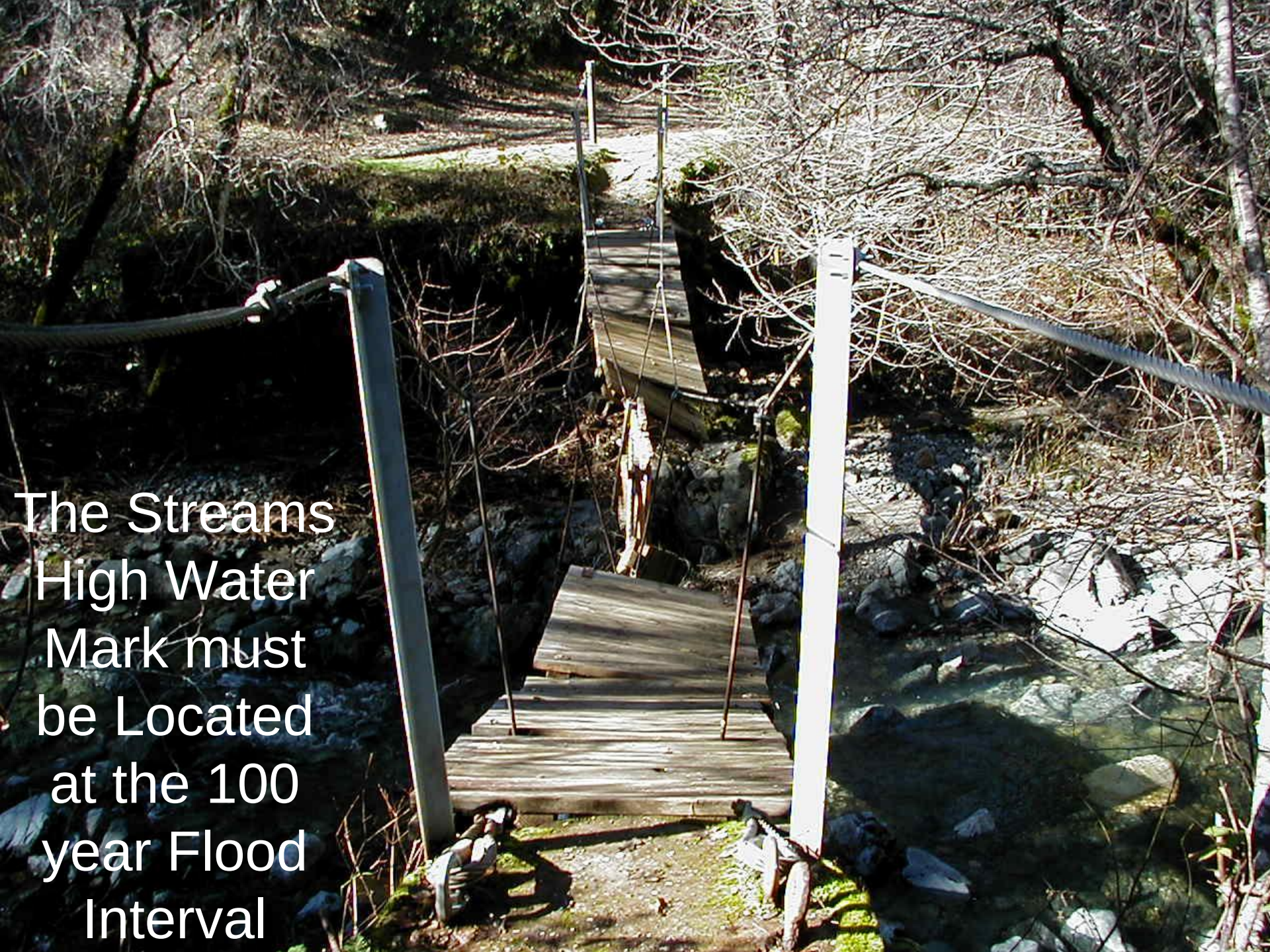
Bridge Structures

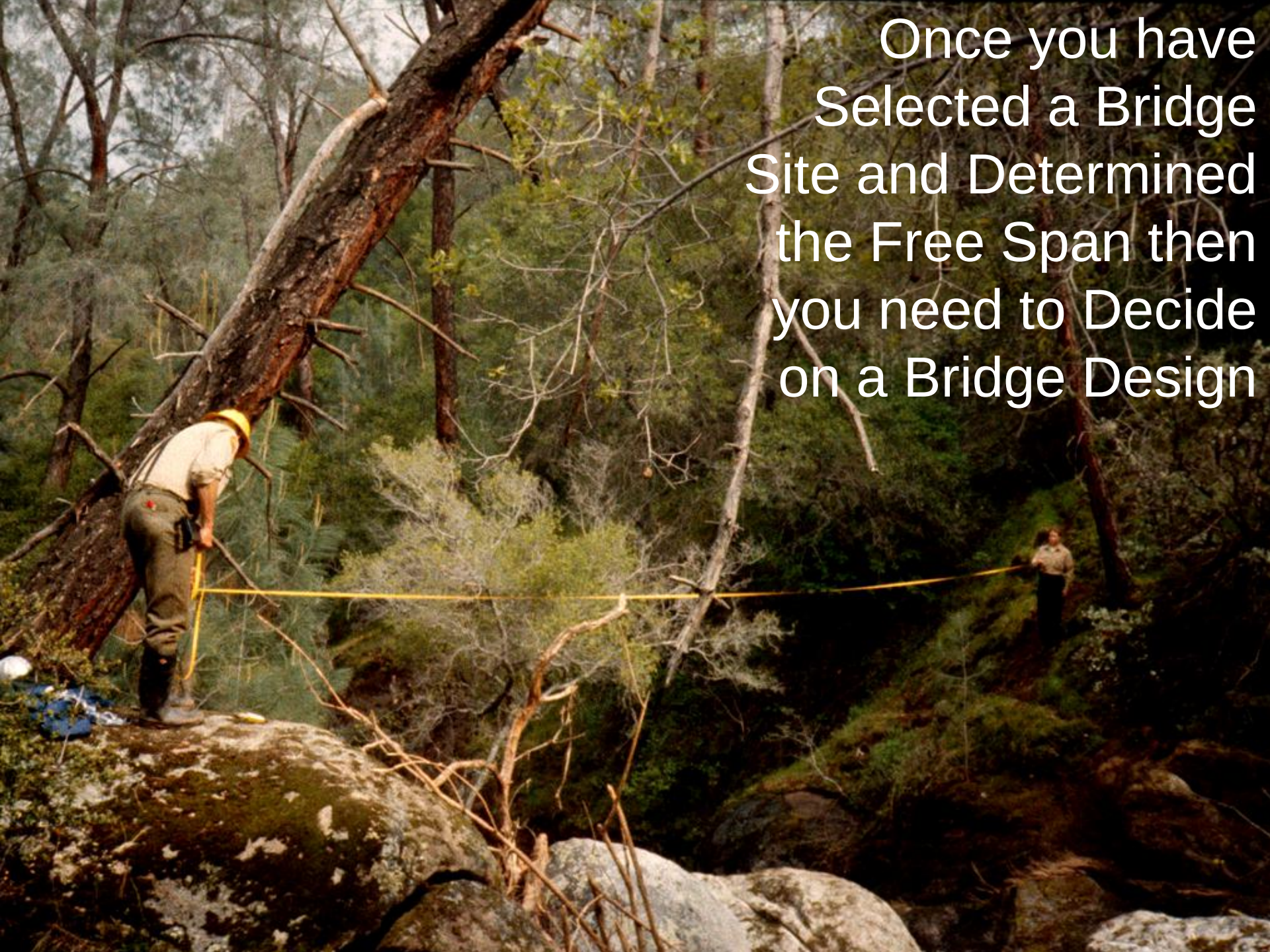

Based
on Varying
Conditions
You Need to
Select a Safe and
Sustainable
Crossing

Before Deciding to Build a Bridge Consider Other Crossing Designs

- Bridges are Expensive to Build and Maintain
- Bridges can have Greater Resource and Visual Impacts

Inner Gorge Areas are Inherently Dynamic or Unstable - Building a Bridge in these Locations Requires a Careful Examination


The Streams
High Water
Mark must
be Located
at the 100
year Flood
Interval


Once you have
Selected a Bridge
Site and Determined
the Free Span then
you need to Decide
on a Bridge Design

Log Crossing

Rustic

Protect Resources

Wilderness/Backcountry

Inyo National Forest,
Bishop California

Simple to Build

Adventuresome to Cross

May not Meet Trail User Safety

Kachemak Bay State Park
Homer Alaska

Cable Bridges

Log Bridge

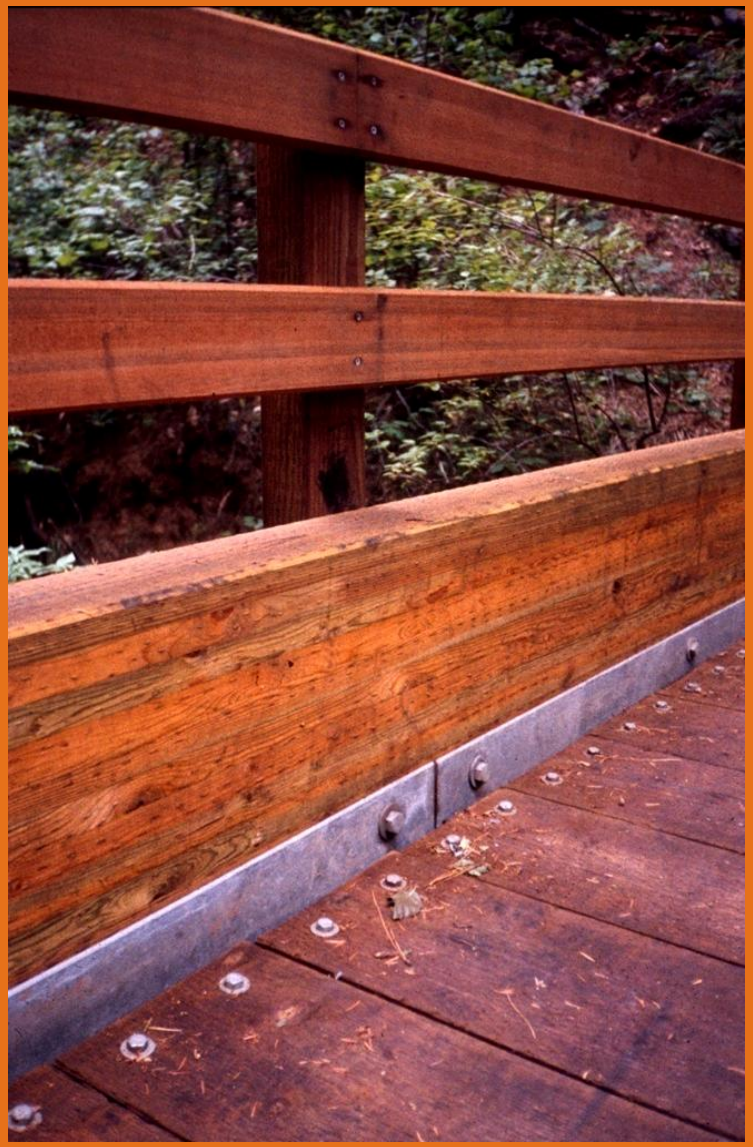
- Good Backcountry Choice
- Uses Native Materials
- Rustic
- Might Violate Resource Policies
- Hard to Verify Structural Integrity
- Assembly Labor Intensive/High Skill

Milled Stringer Bridges

Good for Short to Moderate Spans, Semi- Rustic Appearance, Easy to Assemble and Engineer Load Capacities


Good for Short to Moderate Spans, Semi- Rustic Appearance, Easy to Assemble and Engineer Load Capacities
Glue-laminated Stringer Bridges

Drop down deck design



Steel I-Beam

Wind River
Mountains
Wyoming

- Good Moderate to Long Spans
- Easy to Assemble
- Engineered Load Capacities
- Can be Visually Obtrusive and
- Longer Spans are Limited and Heavy

Prefab Steel

- Good for Short to Long Spans
- Engineered Load Capacities
- Longer Spans are Heavy and Difficult to Place
- Can be Visually Obtrusive

Fiberglass Truss

- Good for Short to Long Spans
- Light Weight
- Easy to Assemble
- Engineered Loads
- Can be Visually Obtrusive
- Longer Spans are Limited

Fiberglass Stringer

Good for Short to Moderate Spans, Easy to Assemble and Engineer Load Capacities

Wood Overhead Truss Bridges

- Good for Short to Long Spans
- Reduce Material Weight
- Engineered Load Capacities
- Higher Skill Level
- Can be Visually Obtrusive

Metal Truss

Suspension Bridge

- Good for Very Long Spans
- Engineered Loading
- Difficult to Build
- Can be Visually Obtrusive


Can Obstruct Stream Channels
Glacier National Park
Mid-Span Supports


Pipe Bridge

Mitigating Resource Impacts

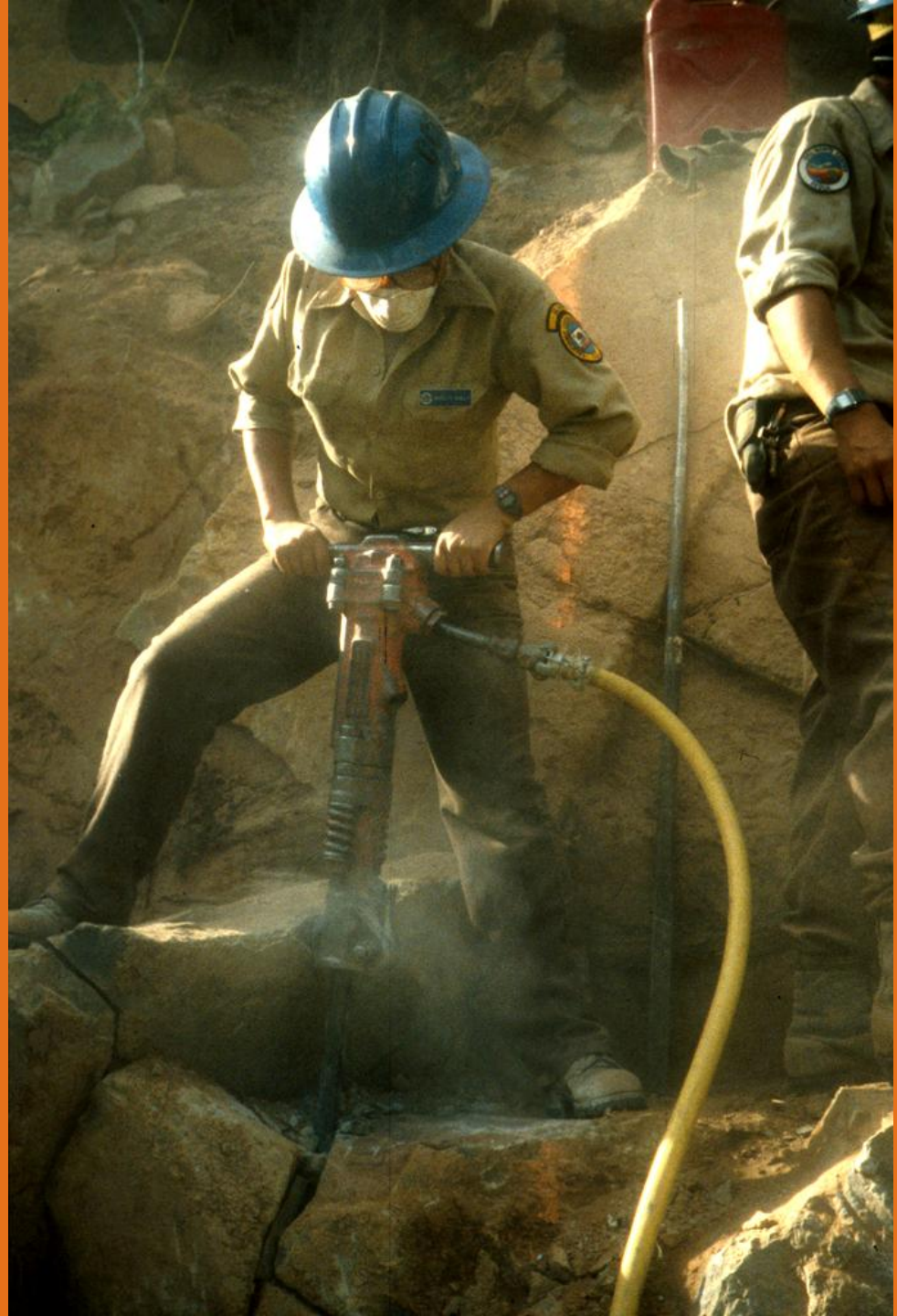
Install:
Silt Fences
Straw Bales
Fabric Drop Cloths

Capture Sediment
Wood Chips
Sawdust
Building Materials

Bridge Abutments

Earth or Soil Abutment

Native Rock Abutments



Concrete Abutments


Humboldt
Redwoods
State Park
Abutments
Located in or
Adjacent to the
Stream
Channel must
Start a
Minimum of
Two Feet
Below the
Scour Line

Rock Wall Abutment

Rocky Mountains National Park

Plastic Wood or Composites are Excellent Abutment Materials

Gabion


Pole (pile) Abutments


Soldier Pile Abutment

Trail Obliteration and Rehabilitation

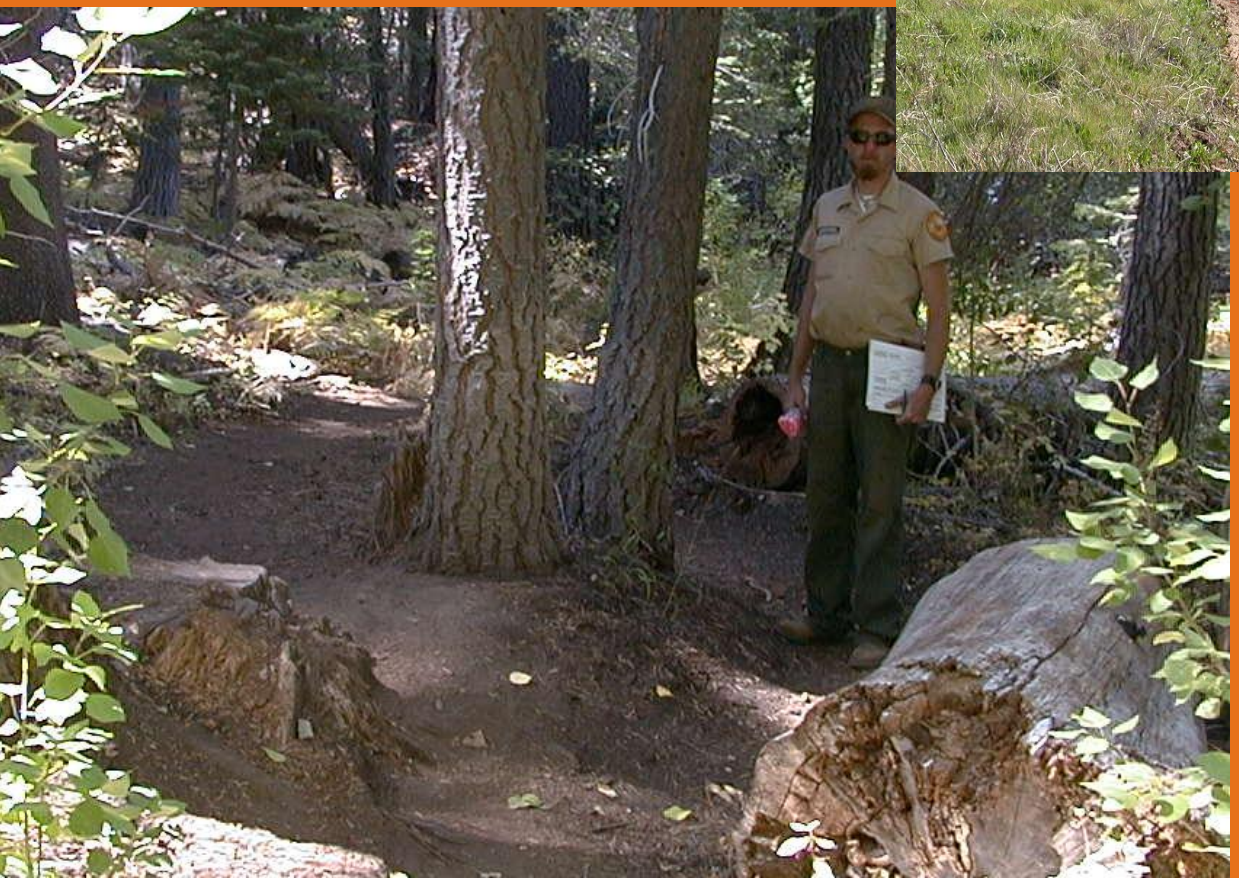
DS

Trail Obliteration and Rehabilitation Session Objectives

- Identify Where and When to Obliterate and Rehabilitate Trails
- Identify Techniques for Trail Obliteration and Rehabilitation
- Understand the Benefits of Full Rehabilitation
- Identify Where to Obtain Vegetation for Obliteration/Rehabilitation Projects
- Review Examples of Trail Obliteration and Rehabilitation Projects

When is trail Obliteration or Rehabilitation Necessary ?

Trail Narrowing and Multiple Trails




When Trails are Rerouted


Volunteer, Way
or User Created
Trail Removal

Work Site Restoration

Work Site Restoration

Finishing and Softening of New Trail Construction

Trail Obliteration and Rehabilitation Process

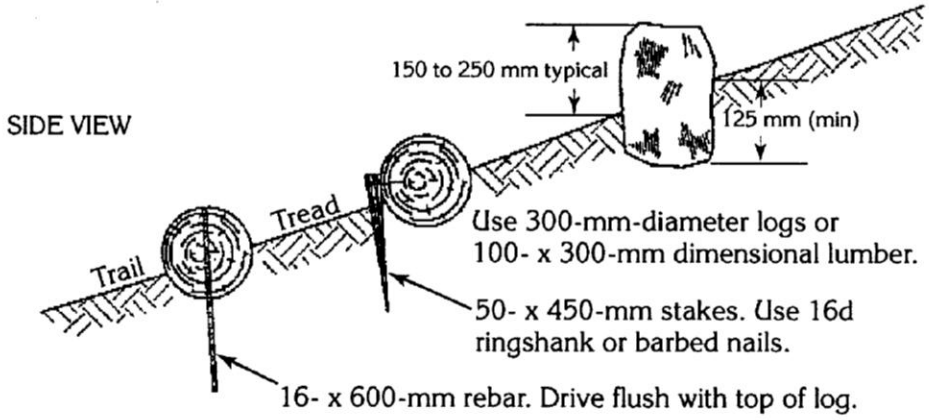
Remove Organics to Prepare Soils
Aerate and De-compact Soils

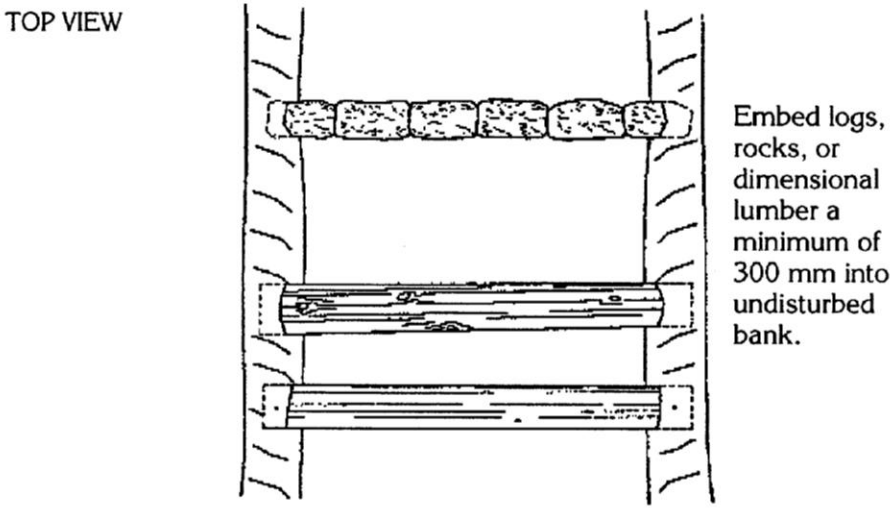
Topographically
Restore
Hydrology

and
Natural
Landforms

Some Cases Check Dams Need to be Constructed to Stop Sub Surface Flow

Check Dams





Topographic Restoration can be Done by Hand or Equipment

Harvest Vegetation from Within Watershed

- Use New Trail Construction Areas First

- If no Harvesting is Possible, Collect Seed and Propagate at Nursery

Perform Rehab Project During Best Season for De-compaction and Re-growth to be Successful


Plant Vegetation
in Random
Manner

Use Woody Debris, Rocks To Discourage Use

Mulch with Native or Weed Free Organics

Sign and Inform Public

Rehabilitation Techniques Work in All Climates

Before

After


Before
After


Before
After

Before

After

Trail Obliteration and Rehabilitation

Summary:

- Good Trail Project Management Always has a Rehabilitation Component
- Use Obliteration and Rehabilitation Techniques to:
  - Narrow Trails
  - Remove Multiple Trails
  - Eliminate Way Trails
  - Eliminate Worksite Impacts
  - Soften New Trail Construction
- Follow Sound Rehabilitation Practices and Establish full Hydrological Restoration

Criteria for Selecting a Trail Structure

Accessibility
Logistics
Esthetics
Cost
Labor Source
Design Effectiveness

KK

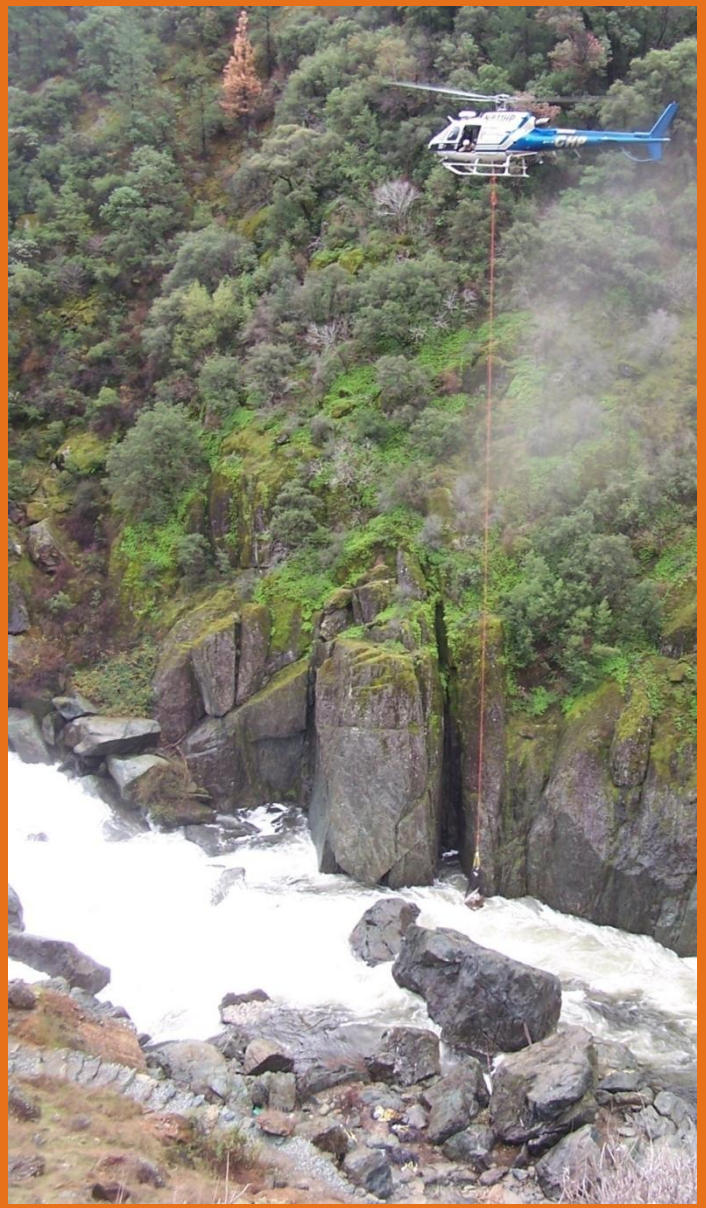
Accessibility

Logistics

Availability
of
Native Materials

Logistics

Distance from the Nearest Trailhead



Logistics

Difficulty of the Terrain

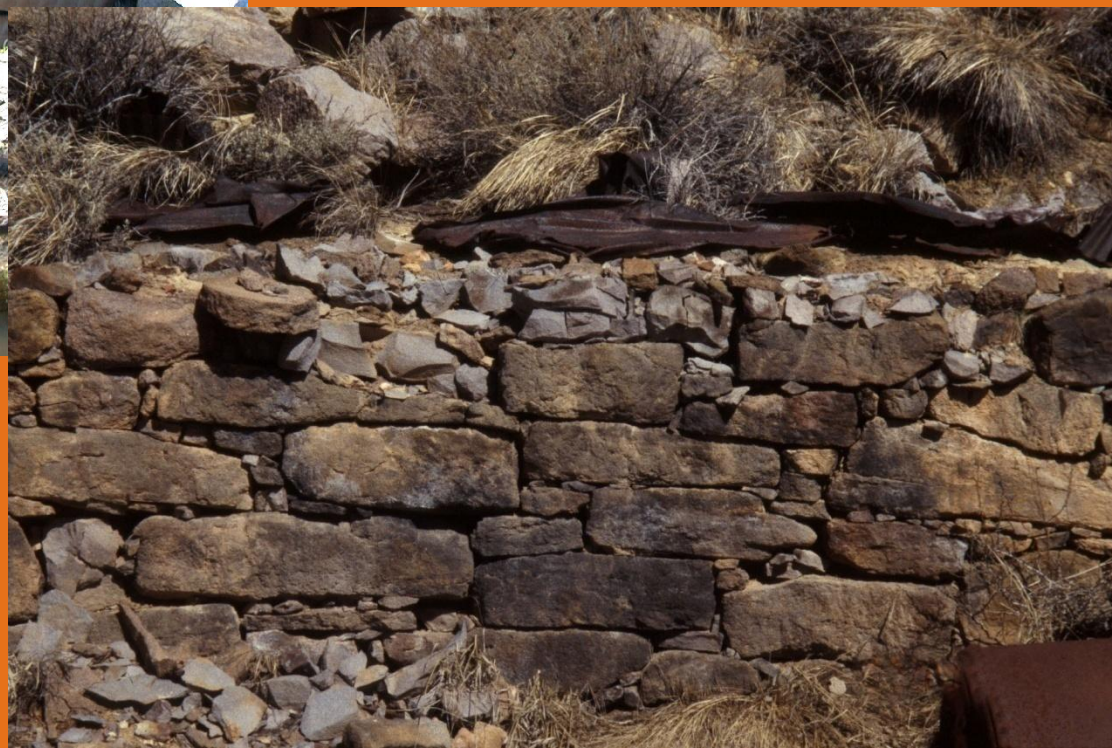
Esthetics

Matching Materials
with the
Natural Features

(soil, rock, trees, vegetation)

Esthetics

Matching
the
Local Architecture



Esthetics

Blending in or Hiding Synthetic Materials

Cost

Expensive to Build
in
Labor or Materials

Cost

Cost of Gathering Local Native Material and Transporting to Work Site

Cost

Cost of Purchasing Non Native Materials and Transporting to Work Site

Cost

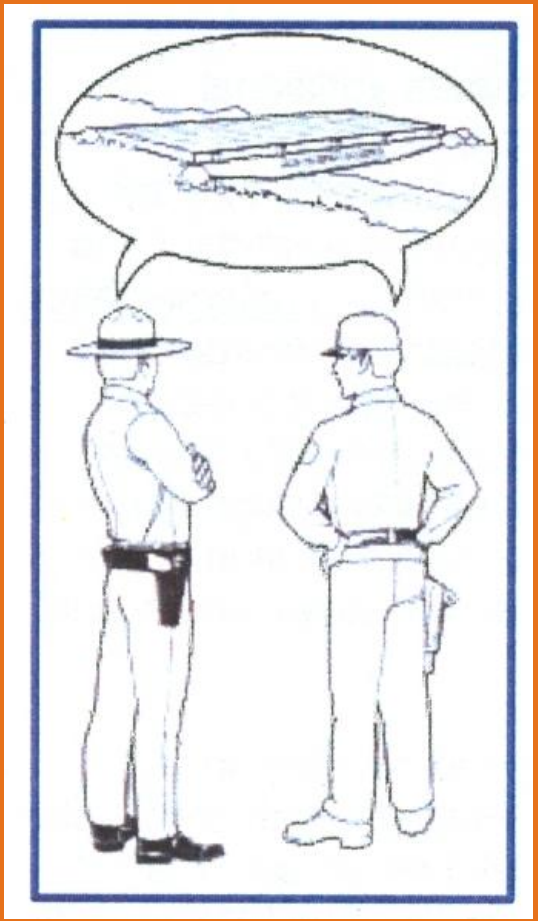
Long Term Maintenance or Replacement cost

Labor Source

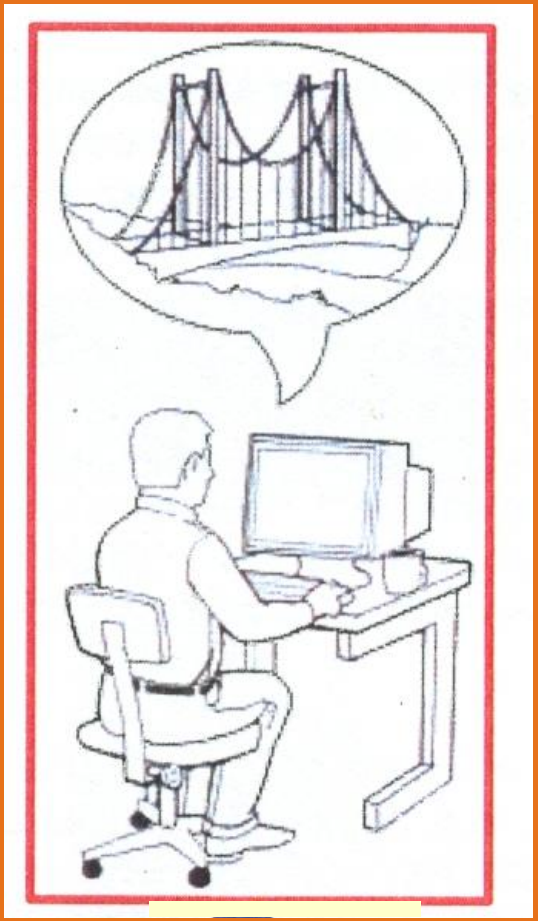
Skill Required
to
Construct your Structure
Needs to Match
your
Labor Source

Design Effectiveness

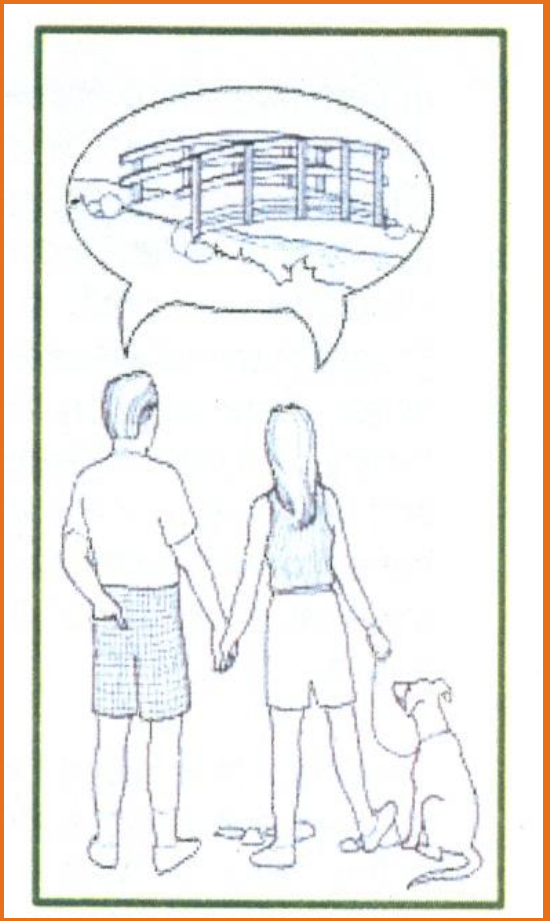
Which Design will Work the Best (Best Solution for the Site)



Need



Design



Design Effectiveness

Trail Structures Summary:

- They are Used when Simple Trail Tread Construction Cannot Produce the Intended Trail Alignment (Start out Simple)
- If Structures are Required Consider Accessibility, Cost, Logistics, Labor force Capabilities, Design Effectiveness and Esthetics
- Prescribing Trail structures Requires a Knowledge of How to Construct the Structure and its Capabilities & Limitations

Construction and Maintenance

Review of Morning Lectures

- Principles of New Trail Construction
- Brushing and Clearing Maintenance
- Drainage Maintenance and Structures
- Tread Maintenance and Structures
- Trail Step Installation
- Retaining Walls
- Handrails
- Puncheons and Bridges
- Rehabilitation